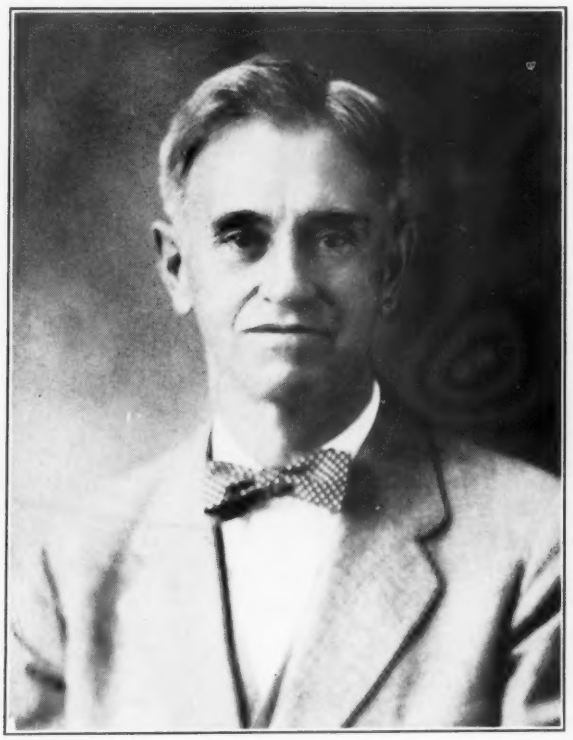
THE BULLETIN

OF THE

AMERICAN CERAMIC SOCIETY

Volume 16 NOVEMBER, 1937 Number 11



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See page 450

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Publication Office: 20th & Northampton Sts., Easton, Pa.
Editorial and Advertising Office: 2525 N. High St., Columbus, Ohio.
Executive Office: 2525 N. High St., Columbus, Ohio.
Committee on Publications: J. D. SULLIVAN, *Chairman;* R. F. SHERWOOD, E. DE F. CURTIS, W. W. WINSHIP, ROSS C. PURDY.

Entered as second-class matter at the post office at Easton, Pa., under the act of March 3, 1879. Published monthly.
Subscription $1.50 a year. Single numbers twenty-five cents
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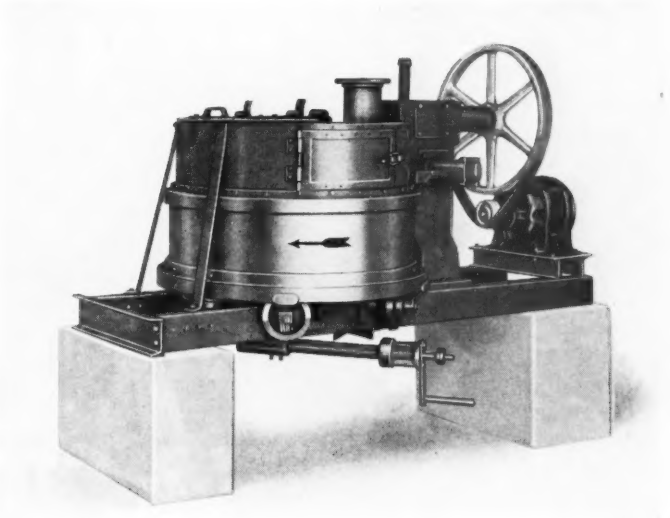

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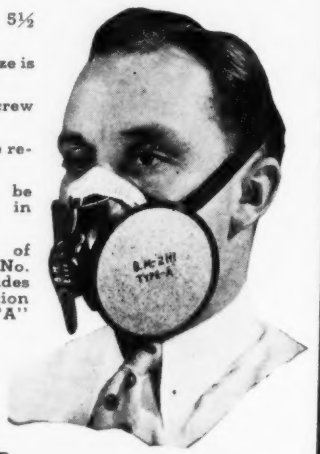

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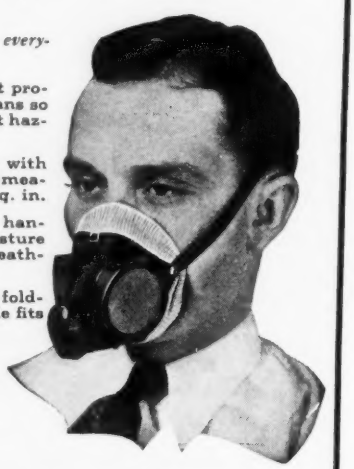

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Paper Makers Importing Co.
Pittsburgh Plate Glass Co.
Potters Supply Co.
Spinks Clay Co., H. C.
United Clay Mines Corp.

Clay (Wad)
Kentucky-Tennessee Clay Co.
Potters Supply Co.
Spinks Clay Co., H. C.
United Clay Mines Corp.

Clay (Wall Tile)
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
Hammill & Gillespie, Inc.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co.
Sant, Richard C.
Spinks Clay Co., H. C.
United Clay Mines Corp.

Cleaners
The Porcelain Enamel and Mfg. Co.

Cleaners, Chemical
Harshaw Chemical Co.

Clocks (Gauge Board)
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.

Cobalt Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
The Hommel Co., O., Inc.
Harshaw Chemical Co.
The Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

Cobalt Sulphate
Harshaw Chemical Co.

Colors
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
The Hommel Co., O., Inc.
Harshaw Chemical Co.
Pittsburgh Plate Glass Co.
The Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

Cones
The Edward Orton, Jr., Ceramic Foundation

Conveying Equipment
Frazier-Simplex, Inc.
Lancaster Iron Works, Inc.

Copper Oxide
Harshaw Chemical Co.

Corhart
Corhart Refractories Co.

Cornwall Stone (Imported)
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Paper Makers Importing Co.

Crucibles (Filter, Melting, Ignition)
Carborundum Co.
Denver Fire Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.
Potters Supply Co.

Crushers (Clay)
Lancaster Iron Works, Inc.

Cryolite (see Kryolith)
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Crystolon (Refractory Products)
Norton Co.

Cullet, Washing Plants, Incinerators, Crushers
Frazier-Simplex, Inc.

Decorating Supplies
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
The Hommel Co., O., Inc.
Harshaw Chemical Co.
Pittsburgh Plate Glass Co.
The Vitro Mfg. Co.

Disintegrators
Lancaster Iron Works, Inc.

Dryer (Pipe Rack)
Lancaster Iron Works, Inc.

Drying Machinery
Frazier-Simplex, Inc.
Lancaster Iron Works, Inc.
Proctor & Schwartz, Inc.

Electrocast Refractories
Corhart Refractories Co.

Enameling Equipment (Complete)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Frazier-Simplex, Inc.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Enameling Furnaces
Carborundum Co.
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Electro Refractories & Alloys Corp.
The Hommel Co., O., Inc.
Lancaster Iron Works, Inc.
Norton Co.

Enameling Iron (Sheet)
American Rolling Mill Co.
Bethlehem Steel Co.

Enameling Muffles
Bethlehem Steel Co.
Carborundum Co. (*Carbofrax*)
Chicago Vitreous Enamel Product Co.
Electro Refractories & Alloys Corp.
Frazier-Simplex, Inc.
Norton Co. (*Alundum*)
Pittsburgh Plate Glass Co.

Enameling (Practical Service)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
The Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

Enamel Oxide
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.

Enamels (Porcelain)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O. Inc.
The Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Equipment (Porcelain Enameling)
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The DeVilbiss Co.
The Hommel Co., O., Inc.

Exhaust Systems
The DeVilbiss Co.

Feldspar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Porcelain Enamel and Mfg. Co.
Sant, Richard C.
The Vitro Mfg. Co.

Fire Brick
Carborundum Co.
Corhart Refractories Co.
Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
Norton Co.

Fire Brick—Process Equipment
Lancaster Iron Works, Inc.

Fire Clay
Spinks Clay Co., H. C.

Flint
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Porcelain Enamel and Mfg. Co.

Flint Pebbles
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Floors (Non-Slip)
Norton Co.

Fluorspar
Harshaw Chemical Co.

French Flint
Consolidated Feldspar Corp.
Paper Makers Importing Co.

Frit
Allied Engineering Co.
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Frosting Mixtures
Harshaw Chemical Co.

Fuel Oil Systems and Control, Stokers
Bethlehem Steel Co.
Frazier-Simplex, Inc.

Furnaces
Allied Engineering Co.
Carborundum Co. (*Carboradiant*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Frazier-Simplex, Inc.
The Hommel Co., O., Inc.

Glass Bending Ovens, Glass Decorating Machines
Frazier-Simplex, Inc.

Glass Equipment
Hartford-Empire Co.
Lancaster Iron Works, Inc.

Glass Melting Pots (Open and Covered)
Pittsburgh Plate Glass Co.

Glass Melting Tanks and Furnaces
Frazier-Simplex, Inc.
Pittsburgh Plate Glass Co.

Glass Thickness Gauge
Bausch & Lomb Optical Co.

Glaze and Body Spar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

Glazes and Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Glaze Spar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Paper Makers Importing Co.

Goggles
Cover, H. S.
Willson Products, Inc.

Gold
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. H. & Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Dept.

Gold Decorations
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Co.
Granulators
Lancaster Iron Works, Inc.
Grinding Wheels
Carborundum Co. (*Carborundum and Aloxite*)
Chicago Vitreous Enamel Product Co.
Norton Co. (*Alundum-Crystolon*)
Hearths
Carborundum Co. (*Carbofrax* heat treating)
Corhart Refractories Co.
Electro Refractories & Alloys Corp.
Norton Co. (*Crystolon*)
Hearths (Fused Al_2O_3, SiC)
Electro Refractories & Alloys Corp.
Hearths (High Aluminous Clay, Electrically Sintered Aluminum Oxide, Silicon Carbide)
Carborundum Co.
Norton Co.
Hose (Air and Fluid)
The DeVilbiss Co.
Hydrofluoric Acid
Harshaw Chemical Co.
Iron Chromite
Harshaw Chemical Co.
Iron (Enameling)
American Rolling Mill Co.
Bethlehem Steel Co.
Iron Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.
Kaolin
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Edgar Brothers Co.
Edgar Plastic Kaolin Co.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
Sant, Richard C.
United Clay Mines Corp.
The Vitro Mfg. Co.
Kellog AA Refractories
Electro Refractories & Alloys Corp.
Kilns, China (Decorating)
Allied Engineering Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
Frazier-Simplex, Inc.
The Hommel Co., O., Inc.
Kiln Furniture (Silicon Carbide, Semi-Silicon Carbide)
Electro Refractories & Alloys Corp.
Kyanite
Celo Mines, Inc.
Kryolith (See Cryolite)
Harshaw Chemical Co.
Pennsylvania Salt Mfg. Co.
Laboratory Ware
Norton Co.
Lehr Tile (High Aluminous Clay, Electrically Sintered Aluminum Oxide, Silicon Carbide)
Carborundum Co.
Electro Refractories & Alloys Corp.
Lehrs
Frazier-Simplex Inc.
Lehrs (Electric or Fuel Heated)
Frazier-Simplex, Inc.
Lehr Loaders
Frazier-Simplex, Inc.
Linings (Furnace Refractory, Block Refractory Plate, Brick and Tile)
Carborundum Co.
Chicago Vitreous Enamel Product Co.
Corhart Refractories Co.
Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
Norton Co.
Pittsburgh Plate Glass Co.
The Vitro Mfg. Co.
Lithium Carbonate
Foote Mineral Co.
Lithium Minerals
Foote Mineral Co.
Magnesia (Fused)
Electro Refractories & Alloys Corp.
Norton Co.
Magnesia (Sintered, Calcined)
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Porcelain Enamel and Mfg. Co.
Magnesite
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.
Magnesite Calcined
Foote Mineral Co.
Magnesium Carbonate
Harshaw Chemical Co.
Manganese
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.
Manganese Dioxide
Foote Mineral Co.
Manganese (Oxide)
Ceramic Color & Chemical Mfg. Co.
Corhart Refractories Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
Masks (Breathing)
The DeVilbiss Co.
Willson Products, Inc.
Metals (Porcelain Enameling)
American Rolling Mill Co.
Bethlehem Steel Co.
Microscopes (Polarizing)
Bausch & Lomb Optical Co.
Minerals
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.
Mixers (Batch)
Lancaster Iron Works, Inc.
Mold Sanders
Lancaster Iron Works, Inc.
Muffles (Furnace)
Allied Engineering Co.
Carborundum Co. (*Carbofrax*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
Frazier-Simplex, Inc.
Norton Co.
Pittsburgh Plate Glass Co.
Muffles (Laboratory)
Electro Refractories & Alloys Corp.
Mullite (Refractories)
Electro Refractories & Alloys Corp.
Muriatic Acid
Denver Fire Clay Co.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Needle Antimony
Harshaw Chemical Co.
Nickel Salts
Harshaw Chemical Co.
Nitrates (Cobalt, Sodium)
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.
Nitre
Harshaw Chemical Co.
Non-Gro Refractories
Electro Refractories & Alloys Corp.
Norbide (Norton Boron Carbide)
Norton Co.
Olivine
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Opacifiers
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.
Overglaze Colors
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Oxides
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
Metal & Thermit Corp.
Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.
Palladium Decorations
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Pins
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
Potters Supply Co.
Platinum Decorations
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Polariscopes
Bausch & Lomb Optical Co.
Frazier-Simplex, Inc.
Porcelain Enameling Service (Practical)
American Rolling Mill Co.
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
The Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.
Porcelain Enamels
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
The Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.
Potash (Carbonate)
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Solvay Sales Corp.
The Vitro Mfg. Co.
Producer Glass Plants
Frazier-Simplex, Inc.
Pug Mills
Lancaster Iron Works, Inc.
Pyrites (Natural Iron Sulphide)
Foote Mineral Co.
Pyrometer Tubes
Carborundum Co.
Electro Refractories & Alloys Corp.
Montgomery Porcelain Products Co.
Pyrometer Tubes (Refractory and Hard Porcelain)
Denver Fire Clay Co.
McDanel Refractory Porcelain Co.
Montgomery Porcelain Products Co.
Norton Co.
Pyrometers (Optical, Radiation, Surface, Immersion, Needle)
Pyrometer Instrument Co.
Pyrometric Cones
The Edward Orton, Jr., Ceramic Foundation
Raw Material Handling Equipment
Frazier-Simplex, Inc.
Lancaster Iron Works, Inc.
Refractometers
Bausch & Lomb Optical Co.
Refractories
Carborundum Co.
Corhart Refractories Co.
Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
Kentucky-Tennessee Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.
Refractory Materials
Carborundum Co.
Chicago Vitreous Enamel Product Co.
Corhart Refractories Co.
Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
Kentucky-Tennessee Clay Co.
Norton Co.
Pittsburgh Plate Glass Co.
Sant, Richard C.
Titanium Alloy Mfg. Co.
Represses (Automatic)
Lancaster Iron Works, Inc.

Respirators
Chicago Vitreous Enamel Product Co.
Cover, H. S.
The DeVilbiss Co.
The Hommel Co., O., Inc.
Willson Products, Inc.

Rutile
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Foote Mineral Co.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Saggers
Carborundum Co.
Electro Refractories & Alloys Corp.
Norton Co.
Potters Supply Co.

Salt Cake
American Potash & Chemical Co.
Harshaw Chemical Co.
The Hommel Co., O., Inc.

Sandblast Helmets
Willson Products, Inc.

Sand Grinder and Sifters
Lancaster Iron Works, Inc.

Saponin
The Hommel Co., O., Inc.

Selenite of Sodium
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Selenium
Ceramic Color & Chemical Mfg. Co
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc. R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Sheets (Enameling Iron)
American Rolling Mill Co.
Bethlehem Steel Co.

Silica (Fused)
Electro Refractories & Alloys Corp.
The Hommel Co., O., Inc.

Silicate of Soda
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
The Hommel Co., O., Inc.
Harshaw Chemical Co.

Silicon Carbide
Carborundum Co.
Electro Refractories & Alloys Corp.
Norton Co.

Silicon Carbide Firesand
Carborundum Co.

Sillimanite Refractories
Electro Refractories & Alloys Corp.

Sillimanite (Synthetic)
Pittsburgh Plate Glass Co.

Slabs (Furnace)
Carborundum Co.
Electro Refractories & Alloys Corp.
Norton Co.
Pittsburgh Plate Glass Co.

Soda Ash
American Potash and Chemical Corp.
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
Solvay Sales Corp.
The Vitro Mfg. Co.

Sodium Antimonate
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Vitro Mfg. Co.

Sodium Fluoride
Ceramic Color & Chemical Mfg. Co.
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Sodium Metasilicate
Harshaw Chemical Co.

Sodium Nitrite
Harshaw Chemical Co.

Sodium Silica Fluoride
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.

Sodium Uranate
Harshaw Chemical Co.

Soot Blowers
Frazier-Simplex, Inc.

Special Machines
Frazier-Simplex, Inc.

Spar
Ceramic Color & Chemical Mfg. Co.
Consolidated Feldspar Corp.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Vitro Mfg. Co.

Spray Booths
The DeVilbiss Co.

Spraying Equipment
The DeVilbiss Co.

Spurs
Potters Supply Co.

Stacks
Lancaster Iron Works, Inc.

Steel Plate Construction
Bethlehem Steel Co.
Lancaster Iron Works, Inc.

Stilts
Potters Supply Co.

Sulfuric Acid
Denver Fire Clay Co.
Harshaw Chemical Co.
The Hommel Co., O., Inc.

Talc
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Paper Makers Importing Co.

Tanks
Frazier-Simplex, Inc.

Tank Blocks
Corhart Refractories Co.
Pittsburgh Plate Glass Co.

Tanks (Pickle)
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.

Tanks for Raw Material Steel or Concrete
Bethlehem Steel Co.
Lancaster Iron Works, Inc.

Tile (Floor)
Norton Co.

Tile (Muffle)
Carborundum Co.
Electro Refractories & Alloys Corp.
Norton Co.

Tile (Refractory)
Carborundum Co. (*Carbofrax*)
Chicago Vitreous Enamel Product Co.
Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
Norton Co.
Pittsburgh Plate Glass Co.

Tile (Wall)
Denver Fire Clay Co.

Tin Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Vitro Mfg. Co.

Titanium
Ceramic Color & Chemical Mfg. Co
Drakenfeld & Co., B. F.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Titanium Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Tri Sodium Phosphate
Harshaw Chemical Co.

Trucks
Lancaster Iron Works, Inc.

Tubes (Insulating)
Carborundum Co.
McDanel Refractory Porcelain Co.
Norton Co.

Tubes (Pyrometer)
Carborundum Co.
Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
McDanel Refractory Porcelain Co.
Montgomery Porcelain Products Co.
Norton Co.
Pittsburgh Plate Glass Co.

Uranium Oxide
Harshaw Chemical Co.

Uronium Oxide (Yellow-Orange-Black)
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
The Vitro Mfg. Co.

Water Softening Plants
Frazier-Simplex, Inc.

Wet Enamel
Ceramic Color & Chemical Mfg. Co.
Chicago Vitreous Enamel Product Co.
The Hommel Co., O., Inc.
The Porcelain Enamel & Mfg. Co.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Whiting
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
Hammill & Gillespie, Inc.
The Hommel Co., O., Inc.
Paper Makers Importing Co.
The Vitro Mfg. Co.

Winding Drums
Lancaster Iron Works, Inc.

Zinc Oxide
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel Co., O., Inc.
The Vitro Mfg. Co.

Zircon
Foote Mineral Co.

Zirconia
Ceramic Color & Chemical Mfg. Co.
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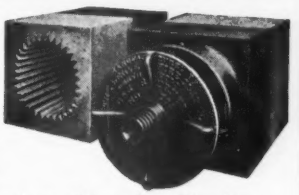

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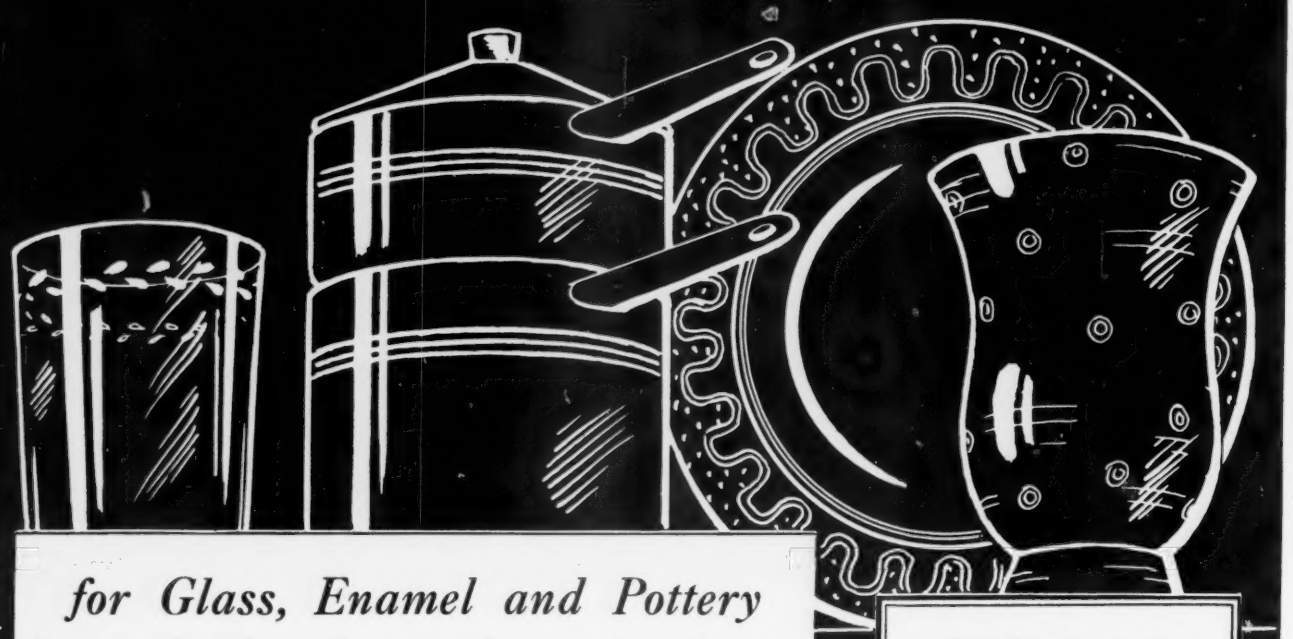

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VOLUME 16 **NOVEMBER, 1937** **NUMBER 11**

PAPERS

PHYSICAL PROPERTIES OF SILICON-CARBIDE REFRACTORIES*

By H. N. Baumann, Jr., and J. P. Swentzel

Abstract

The physical properties and engineering data of silicon-carbide refractories, particularly those of the bonded type containing at least 85% silicon carbide, which is now recognized as standard commercially, are compiled. The principal ceramic and metallurgical applications of these refractories are enumerated. The data presented are a compilation of previously published material from widely scattered sources, presented as far as possible in the form of graphs and tables.

I. Introduction

(1) History

The possibility of utilizing silicon carbide as a refractory material was recognized by Acheson,[1] and Tone, on the occasion of his reception of the Acheson Medal,[2] reviewed the development of silicon-carbide refractories. Geiger[3] described their history up to 1923, the pioneer stage of their development. The research and development of what was still a new product was delayed during the period of the World War.

Tone's patent[4] of 1916 covered graded silicon-carbide grain to give a maximum density, less than 10% of refractory clay, high vitrifying temperature, and a bulk specific gravity of not less than 2.3. Any article which meets these specifications can be considered to be a high-grade silicon-carbide product.

(2) Manufacture of Silicon Carbide

Fitzgerald,[5] in 1912, indicated that, because silicon carbide has no melting point and requires an extremely high formation temperature, the resistance furnace is the only type feasible in which to produce silicon carbide. The chief raw materials for the manufacture of silicon carbide are sand and coke, the silica and carbon being in approximately molecular proportions. The crude product is crushed to form grain and this prepared by screening, etc., as the raw materials to be used for bonded silicon-carbide refractories.

(3) Chemistry of Silicon-Carbide Formation

The latest published work is that of Ruff,[6] who summarized the recent researches on silicon carbide by other investigators, described a number of recent experiments of his own, and brought his conclusions up to date. Ruff states that the decomposition of silicon carbide under reducing conditions at atmospheric pressure does not become appreciable until 2500°C and that complete dissociation does not occur until about 2700°C, a

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 24, 1937 (Refractories Division). Received May 24, 1937.

[1] E. G. Acheson, "Production of Artificial Crystalline Carbonaceous Materials," U. S. Pat. 492,767, Feb. 28, 1893.

[2] F. J. Tone, "Super-Refractories," *Trans. Electrochem. Soc.*, **68**, 22–26 (1935).

[3] C. F. Geiger, "History of Development of Silicon-Carbide Refractories," *Jour. Amer. Ceram. Soc.*, **6** [1] 301–306 (1923).

[4] F. J. Tone (Carborundum Co.), "Silicon-Carbide Refractory Article," U. S. Pat. 1,204,211, Nov. 7, 1916.

[5] F. A. J. Fitzgerald, "Crystalon-Silicon Carbide," *Met. Chem. Eng.*, **10** [9] 519–21(1912).

[6] Otto Ruff (Director of Inorganic Chemical Laboratories, Breslau Institute of Technology), "Formation and Dissociation of Silicon Carbide," *Trans. Electrochem. Soc.*, **68**, 87–109 (1935).

value that has been confirmed by other recent workers but is considerably higher than was previously accepted. The formation of silicon carbide itself, Ruff indicates, takes place entirely in the gaseous phase.

Ridgway[7] has reported the most recent and complete measurements on the temperature gradient of the commercial silicon-carbide furnace, and he has shown that the silicon-carbide zone never reaches a temperature much above 2000°C in any of the furnaces that he examined, a temperature at which it is held during the period of crystal development. The physical chemistry of recrystallization on which the development of large silicon-carbide crystals depends is still a matter of research.

(4) Silicon-Carbide Crystals

Baumhauer[8] recognized three morphological modifications. Previously it was thought that crystalline silicon carbide always occurred as crystals in the rhombohedral class of the hexagonal system, the crystals having a rhombohedral angle of almost 90°. Baumhauer's three modifications are found intergrown and twinned. Hauer,[9] working with Baumhauer's material by X-ray diffraction methods, published Laue photographs that were made perpendicular to the basal pinacoid and showed three types of symmetry. Ott[10] using the powder method, claimed that what was previously called "amorphous silicon carbide," *i.e.*, the grayish green material found in "fire sand" has a cubic crystalline structure. Ott,[11] in 1928, announced a fifth modification which was hexagonal.

Wyckoff[12] summarized the X-ray diffraction data on silicon-carbide hexagonal unit cells in Table I.

TABLE I

Modification	a_0	c_0	No. of mol.
I	3.09 A	37.9 A	15
II	3.09 A	15.17 A	6
III	3.09 A	10.10 A	4
V	3.09 A	129.0 A	51

Wyckoff points out that the bases of all four cells have the same dimensions and remarks on the extraordinary height of Ott's modification V. He questions whether the structures indicated for these modifications will prove finally to be correct, because "SiC is the only simple substance to have units of such great complexity."

In their physical properties, the four hexagonal modifications of silicon carbide are much the same and can not be distinguished by petrographic means. Under the microscope, they are uniaxial positive with unusually high birefringence and dispersion, the following refractive index data being given by Merwin.[13]

TABLE II

Wave length = 755	671(Li)	589(Na)	535(Tl)	586(F)	Dispersion F–C (486–656)
N_e = 2.654	2.673	2.697	2.721	2.749	0.072
N_0 = 2.616	2.633	2.654	2.675	2.700	0.064
N_e–N_0 = 0.038	0.040	0.043	0.046	0.049	0.008

(5) Silicon-Carbide Grain

Silicon-carbide crystals vary in color from black to almost clear white, but commercially they are either black or green, the differences in color being due to included foreign matter. Hoffmann[14] states that the black variety is used almost exclusively in America for refractory grain, while in Norway and Germany the green variety is used. Silicon-carbide grain contains impurities, generally in very small amounts. He sorted green Norwegian refractory grain recently, and found that they contained a considerable amount of black and yellow crystals. The results of his analysis are given in Table III.

TABLE III

	Black crystals (%)	Green crystals (%)	Yellow crystals (%)	Original mixture (%)
SiC	96.41	97.81	98.83	97.70
Al_2O_3	0.31	0.18	1.17	0.31
Fe	0.22	0.21	0.09	0.26
CaO	0.21	0.63	0.32	0.34
S	0.09	0.09	0.34	0.27
C	2.64	1.27	0.29	1.02
Free Si	0.08	0.42	0.31	0.49
Free SiO_2	0.32	0.31	0.28	0.35

The presence of sulfur and such an unusual amount of lime in these analyses is not generally found in silicon-carbide grain, but the other constituents are normal. In common with other

[7] R. R. Ridgway, "Temperature Measurements in Commercial Silicon-Carbide Furnaces," *Trans. Electrochem. Soc.*, **61**, 217–32 (1932); *Ceram. Abs.*, **11** [8] 459 (1932).

[8] H. Baumhauer, "Verschiedenen Modifikationen des 'Carborundums' und Erscheinung der Polytypie," *Z. Krist.*, **55** [3] 249–59 (1915).

[9] F. Hauer and P. Koller, "Röntgenogramme von Karborundkrystallen," *ibid.*, **55** [3] 260–63 (1920).

[10] H. Ott, "Structure of Carborundum: III, Third Modification and Amorphous Carbide," **63** [1] 1–18 (1926); *Ceram. Abs.*, **5** [12] 422 (1926).

[11] H. Ott, "New Modification of Silicon Carbide" from Festschrift, p. 303. Pub. by Arnold Sommerfeld, 1928.

[12] Ralph W. G. Wyckoff, Structure of Crystals, p. 222. 2d ed. Chemical Catalog Co., New York, 1931.

[13] H. E. Merwin, "Dispersion and Other Optical Properties of Carborundum," *Jour. Wash. Acad. Sci.*, **7**, 445 (1917).

[14] Herbert Hoffmann, "Über die Zerstörung der Silicium Carbid-Steine in Temperaturbereich 900–1000°C." Doctor's thesis, Tech. Hochschule, Brunswick, Germany, 1934.

authorities, Hoffmann considers the carbon to be dispersed in colloidal particles within the silicon-carbide crystals, particularly in black crystals.

In Holler's[15] recent work on the thermal conductivity of silicon-carbide brick, he gives the following analysis of clean, high-grade SiC of the green type. Note the absence of sulfur and the very small amount of lime.

TABLE IV

	(%)		(%)
SiC	97.71	MgO	Trace
Al_2O_3	0.32	S	Trace
Fe	0.16	C	0.18
Fe_2O_3	0.52	Si	0.58
CaO	0.03	SiO_2	0.49

Hoffmann also determined the true specific gravity of these crystals at 20°C, and it may be seen that the included impurities have small effect on the grain density.

TABLE V

	Specific gravity
Silicon carbide black	3.217
" " green	3.214
" " yellow	3.219
" " original mixture	3.218

II. Recrystallized Silicon-Carbide Refractories

The early successful uses of shaped refractory articles were chiefly in the form of recrystallized silicon carbide,[16] which refractory has the highest load-carrying capacity at high temperatures and remains rigid at temperatures at which other refractories fuse. Its chief defects are numerous large pores, and it is susceptible to excessive oxidation at the temperatures ordinarily used for refractories (900° to 1400°C). Tone[17] developed his process of silicidizing in 1911. This method consists of forming silicon-carbide shapes from carbon in an atmosphere of silicon vapor, producing a refractory resembling Fitzgerald's but denser.

Until the modern bonded, dense, high SiC product was developed, considerable recrystallized silicon-carbide refractories, of the Fitzgerald and Tone types, were used, the latter especially for pyrometer tubes and similar special shapes. Benner[18] has a method for making a denser type of recrystallized silicon-carbide refractory.

III. Bonded Silicon-Carbide Refractories

Grade A bonded SiC product contains 85% or more of SiC, grade B bonded SiC contains between 70 and 80% SiC, and semi silicon-carbide refractory contains 50% or less of SiC.[19]

Walton[20] distinguishes between bonded silicon carbide and silicon carbide incorporated in a clay body, the latter comprising plastic bodies containing from 10 to 70% SiC.

Tone[21] patented the use of superficially oxidized or amorphous silicon-carbide bond, and Balz,[22] in 1917, patented the use of alkaline earth hydrates. Geiger,[23] in 1925, patented the use of a synthetic sillimanite (mullite) bond, formed by the reaction of alumina and superficially oxidized silicon-carbide grains. Hartmann,[24] in 1931, used treated silicon-carbide grain. Forse,[25] in 1932, fired with a minimum of oxidation of the refractory grain previous to vitrification, and Tone,[26] in 1932, made one of the major recent advances in producing dense, bonded silicon-carbide refractories by using "mulled grain."

Bonded silicon-carbide refractories, particularly those of "grade A," are now almost always protected by a refractory type of glaze. Forse[27] used a thin coating of finely divided silicon carbide. Martin[28] covered the surface of the refractory with a magnesium compound and a fluxing

[15] Fritz Holler, "Thermal Conductivity of Technical Silicon-Carbide Brick," *Sprechsaal*, **69** [50] 733–35; [51] 745–47; [52] 761–62 (1936); *Ceram. Abs.*, **16** [6] 177 (1937).

[16] F. A. J. Fitzgerald, "Silicon-Carbide Article," U. S. Pat. 650,235, May 22, 1900.

[17] (*a*) F. J. Tone, "Method for Production of Dense Compacted Silicon Carbide," U. S. Pat. 992,698, May 16, 1911.

(*b*) F. J. Tone and B. Allen, "Process of Silicidizing," U. S. Pat. 1,054,372, Feb. 25, 1913.

[18] R. C. Benner, G. J. Easter, and J. A. Boyer (Carborundum Co.), "Silicon-Carbide Refractory and the Process of Manufacture," U. S. Pat. 2,015,778, Oct. 1, 1935; *Ceram. Abs.*, **15** [1] 26 (1936).

[19] Classifications along these general lines may be found in the trade literature and advertisements of various manufacturers.

[20] S. F. Walton and E. L. Haumann, "Observations on Effect of Silicon Carbide in Clay Bodies," *Jour. Amer. Ceram. Soc.*, **13** [12] 935–40 (1930).

[21] F. J. Tone, "Self-Bonded Silicon-Carbide Article," U. S. Pat. 772,262, Oct. 11, 1904.

[22] G. A. Balz, "Silicon-Carbide Article and Process of Making It," U. S. Pat. 1,217,683, Feb. 27, 1927.

[23] C. F. Geiger (Carborundum Co.), "Refractory Article and Method of Making the Same," U. S. Pat. 1,546,-833, July 21, 1925.

[24] M. L. Hartmann (Carborundum Co.), "Silicon-Carbide Articles and Method of Making the Same," U. S. Pat. 1,790,474, Jan. 27, 1931; *Ceram. Abs.*, **10** [4] 277 (1931).

[25] E. B. Forse and C. F. Geiger (Carborundum Co.), "Refractory Containing Silicon Carbide and Method of Making the Same," U. S. Pat. 1,849,289, March 15, 1932.

[26] F. J. Tone, "Low Permeable Refractory and Method of Making the Same," U. S. Pat. 1,873,071, Aug. 23, 1932.

[27] E. B. Forse (Carborundum Co.), "Refractory Article," U. S. Pat. 1,473,286, Nov. 6, 1923.

[28] R. H. Martin (Norton Co.), "Refractory Article and Method of Protecting the Same," U. S. Pat. Reissue 17,-661, May 13, 1930; *Ceram. Abs.*, **9** [7] 541 (1930).

agent. Walton[29] coated the clay bonded silicon-carbide body with prefired aluminum silicate of substantially the same composition as the bond. Benner[30] used a glaze to minimize the oxidation of the silicon-carbide grain during the vitrification of the bond.

IV. Effect of Gases and Fluxes

That silicon-carbide grain is subject to destruction by oxidation at certain temperatures is its one serious defect as a refractory. Hoffmann[14] reviewed the previous literature on the effect of oxygen on this grain, and noted that LeChatelier demonstrated that oxygen had no effect until 1000°C, and only a slow oxidation at higher temperatures, that Niederleuthner confirmed this in general and said that the oxide film retarded oxidation at higher temperatures, and that Ballard and Ridgway claimed no attack up to 800°C. Hoffmann's experiments using clean, CO_2-free, but moist oxygen showed no apparent oxidation up to 1200°C.

Hoffmann conducted numerous experiments on the effect of gases on silicon carbide, both as grain and as bonded brick in the temperature range 900° to 1200°C, and showed that water-vapor, even under high pressure, had no effect up to 1000°C. A silicon-carbide brick heated for 600 hours at 1200°C in an atmosphere of CO_2 showed no attack. He was able to simulate service destruction only in one way, namely, by spraying the heated, bonded silicon-carbide brick with water to which hydrogen sulfide and lime were added.

Hoffmann also made use of a previously devised method for detecting solid-phase reactions up to 1300°C in which he studied the effect on silicon-carbide powders of various materials, such as Al_2O_3, MgO, Fe_2O_3, $CaSO_4$, CaS, and CaO. The method consisted in plotting two curves, one the heating curve of the furnace, and another for the mix. When no reaction takes place the two curves are parallel; when a reaction takes place the mix curve shows a directional change. The only materials that showed reactions were Fe_2O_3 and CaO. The iron oxide reaction was exothermic and took place at 1000° to 1200°C; the lime reaction, which occurred at 525°C, did not take place until the lime and silicon carbide were equal in amount; it was an endothermic reaction and therefore not an oxidation. It may have been a reaction with the impurities associated with the grain.

V. Bonded Silicon Carbide as a Boiler-Wall Refractory

The application of silicon-carbide brick to boiler walls was one of the first, and remains one of the more important, uses. Powell,[31] in his critical analysis of boiler-furnace refractories, stated that silicon carbide was the most widely used and until recently the only special refractory available. Since then, air-cooled walls, higher ratings, and the use of pulverized coal have increased the use of silicon carbide as a boiler-furnace wall refractory. Johnson[32] summarized the chief surveys on the cause of coal-fired boiler-furnace wall failure; he showed that the chief cause was slag adhesion, especially when the eastern bituminous coals were used, and erosion was the chief cause in the mid-western coals. It was early found that adhesion and the building up of clinkers could be largely eliminated by using silicon-carbide brick at the "fire line." White[33] says that this is caused by a slight reducing action at the slag-refractory interface so that it is impossible for the oxide of the coal ash to stick to the silicon carbide. Johnson[32] states that when boilers are operated at high ratings, air-cooled walls have solved the refractory problem, and he also points out that silicon carbide, on account of its high heat conductivity and great physical strength, makes effective thin, high heat conducting air-cooled walls. Hawke[34] shows air-cooled walls being used to furnish preheated air directly to the fuel bed. In the Bernitz type of air-cooled wall for boiler furnaces, silicon-carbide refractories have almost completely replaced fire clay from which this type of wall was

[29] S. F. Walton (Exolon Co.), "Method of Applying Protective Refractory Glaze to Refractory Bodies Containing Silicon Carbide," U. S. Pat. 1,868,451, July 19, 1932; *Ceram. Abs.*, **11** [10] 533 (1932).

[30] R. C. Benner and H. N. Baumann, Jr. (Carborundum Co.), "Glazed Refractory Article and Method of Making the Same," U. S. Pat. 1,975,069, Oct. 2, 1934.

[31] E. B. Powell, "Boiler-Furnace Refractories," *Trans. Amer. Mech. Eng.*, **47**, 839–948 (1925); *Ceram. Abs.*, **5** [10] 335 (1926).

[32] B. M. Johnson and J. A. King, "Use of Silicon-Carbide Refractories in Boiler Furnaces," *Jour. Amer. Ceram. Soc.*, **10** [12] 1007–15 (1927).

[33] H. E. White, "Development of Some Special Refractories," *Fuels & Fur.*, **9** [9] 1061–66 (1931); *Ceram. Abs.*, **11** [3] 180 (1932).

[34] (*a*) C. E. Hawke (Carborundum Co.), "Furnace Wall Construction," U. S. Pat. 1,833,677, Nov. 24, 1931; *Ceram. Abs.*, **11** [2] 117 (1932).

(*b*) C. E. Hawke, "Furnace and Method of Operating the Same," U. S. Pat. 1,828,839, Oct. 27, 1931.

[35] B. H. Snow (Bernitz Furnace Appliance Co.), "Furnace Wall," U. S. Pat. 1,627,349, May 3, 1927.

originally constructed. Snow[35] utilized the great strength of silicon carbide at high temperatures, employing a block with a relatively thin fire face; the high thermal conductivity of silicon carbide permitted adequate cooling of the fire face by means of air passed through ducts in the walls. Johnson[32] also speaks of the application of silicon-carbide brick to the water-wall type of furnace having high ratings, both in powdered-coal and in stoker-fired installations. By facing the water-wall tubes with silicon-carbide refractories, a high heat transfer is maintained, the building up of clinker is avoided, and the tendency of the bare tubes to cool the burning fuel too greatly is overcome. Walker[36] discusses the advantages of silicon carbide in air-cooled walls, and also speaks of the advantages of the hardness of these refractories in resisting the effect of erosion.

Stromberg,[37] using powdered coal in combination with an oil burner, impinged a stream of molten ash high in iron against test panels at 1350°C for periods of 48 hours. He found that, while a high-grade clay brick was eroded for a depth of one inch and silica for a depth of $^3/_4$ inch, the erosion of the silicon-carbide brick was negligible.

Fettke[38] reported a comprehensive study on the slagging action of western Pennsylvania coals on different refractories. He made use of a down-draft cylindrical-shaped, powdered-coal furnace. His face temperatures varied from 2256° to 2795°F. He measured erosion loss (1) by measuring the volume before and after testing by means of a mercury balance and (2) by linear measurements. The relative order of increasing slag resistance is as follows: forsterite, silica, chromite, magnesia, high heat duty flint fire clay, super-fire clay, intermediate mullite, high alumina (diaspore type), bonded electrically fused alumina, bonded mullite, cast mullite, and silicon carbide.

VI. Silicon-Carbide Refractories in Gas Generators

Hartmann[39] described this development, giving examples of the use of both plain solid walls and of air-cooled walls. These latter were the "Bernitz" type of block. Jones[40] tabulated cost figures showing the economy of silicon carbide over clay for these particular installations, notwithstanding a much higher first cost.

Knollman[41] described the use of silicon-carbide refractories as checker brick in gas manufacture and stated that his tests indicated that this type of refractory presents excellent possibilities of materially increasing oil-gas generator capacity and efficiency of operation, but that the design and operation of the generator must be adapted to the material.

In the conclusion of his study of checker brick for carburetors of water-gas machines, Parmelee[42] states,

> "Of a number of special refractories which were tested, only bonded soapstone and bonded silicon carbide gave promise of usefulness. Bonded silicon-carbide brick showed superiority in surface deterioration; when used in the three upper courses could be expected to last twice as long as a fireclay checkerwork and might be used economically in some carburetors."

VII. Use of Silicon Carbide in the Ceramic Industry

Silicon-carbide grain, used as a grog ingredient of saggers, gives good heat transmission, high strength, thin walls, and high resistance to thermal shock. Tone[43] largely overcame discolored ware by specifying that the silicon-carbide grain should constitute less than 60% of the mix and should be substantially coarser than 60-mesh. Recently Allesandri,[44] in Italy, was successful in using saggers of bonded silicon carbide for firing porcelain, particularly large pieces. His saggers contain only 10% bond, which consists of a washed, plastic refractory clay, low in magnesia and lime, and 90% treated grain, free of real fine sizes. The saggers were made by pressing. During a period of two years, Allesandri states that the average sagger was used a total of more than one hundred times.

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[36] J. Walker, "Silicon-Carbide Refractories and Their Application to Boiler Furnaces," *Steam Eng.*, **3** [8] 241–42 (1934); *Ceram. Abs.*, **15** [10] 303 (1936).

[37] B. W. Stromberg, "Furnace Testing Refractories for Slag Erosion," *Chem. Met. Eng.*, **37** [11] 685–86 (1930); *Ceram. Abs.*, **10** [2] 123 (1931).

[38] C. R. Fettke and W. E. Stewart, "Slagging Action of Western Pennsylvania Coals on Different Types of Refractories in a Small Pulverized Coal Installation" (Mining and Met. Investigation), *Carnegie Inst. Tech. and Mining & Met. Advisory Boards Bull.*, No. 73 (1936); Pittsburgh, Pa.

[39] M. L. Hartmann and J. A. King, "Silicon-Carbide Refractories for Water-Gas Generators," *Jour. Amer. Ceram. Soc.*, **9** [11] 758–65 (1926).

[40] H. C. Jones, "Economics of Silicon Carbide and Clay for Generator Linings," *New England Gas News*, pp. 39–45, Feb., 1936.

[41] H. J. Knollman, "Use of Super-Refractories as Checker Brick in Gas Manufacture," *Jour. Amer. Ceram. Soc.*, **10** [4] 299–308 (1927).

[42] C. W. Parmelee, A. E. R. Westman, W. H. Pfeiffer, "Investigation of Checker Brick for Carburetors of Water-Gas Machines," *Univ. of Ill. Eng. Expt. Sta. Bull.*, No. 179 (1928); Urbana, Ill.

[43] F. J. Tone, "Refractory Article," U. S. Pat. 1,296,715, March 11, 1919.

[44] E. Allesandri, "Refractory Sagger of Silicon Carbide," *Ind. Vetro. Ceram.*, **7**, 408 and 448 (1936).

Silicon-carbide setting tile, batts, etc., have high moduli of rupture, and therefore are considerably thinner than other refractories. In 1934, Forse[45] patented a kiln-furniture setting of bonded silicon carbide especially applicable to tunnel kiln cars. Diamond[46] has described the use of bonded silicon carbide for open settings, pointing out the special advantages of "class A" (85% + SiC) material.

The use of silicon-carbide muffles for enameling is well known. Its use for glass annealing leers is more recent; a successful installation of that kind at Muncie, Indiana, has been described.[47] The Cannon "Carboradiant" type of combustion chamber, which takes advantage of the high heat conductivity and high emissivity of silicon carbide, has wide use in ceramic manufacture in the firing of a variety of ware including terra cotta, stoneware, sanitary ware, enamels, etc.

An installation of seventeen "Carboradiant" type periodic kilns that replaced twenty-two periodic clay muffle kilns at the Fords Porcelain Works at Perth Amboy, New Jersey, has been described.[48] In many instances, instead of "Carboradiant" periodic furnaces, muffle-type tunnel kilns are being introduced in the manufacture of sanitary ware, wall tile, pottery, etc., the walls of both the preheating and cooling zones being constructed of thin-walled, bonded, silicon-carbide tile.

Silicon-carbide refractories are also finding use in other mineral industry fields.[49]

VIII. Use of Silicon Carbide in Metallurgical Industries

The application of silicon carbide in the metallurgical industries was reviewed by Houchins[50] in 1932.

Generally, where there is danger of the refractory coming in contact with the iron and lime slags associated with ferrous metallurgy, silicon-carbide refractories are to be avoided, although there are exceptions even to this rule; for example, in pyrometer protection tubes and in special shapes where the advantages of abrasion resistance, conductivity, spall resistance, and freedom from slag adhesion takes precedence over the tendency to be eroded by basic fluxes.

White[51] has described at considerable length and thoroughness the use both of cements and prefired shapes of silicon carbide in nonferrous industries. Bruderlein[52] describes in detail the practice at the Amarillo plant of the American Smelting and Refining Co. (See also Bunce[53] and Peirce.[54])

IX. Silicon-Carbide Graphite Refractories

White[55] states that since the World War a supergraphite crucible has been developed. The addition of silicon carbide increased the heat conductivity and strength of the crucible and, by allowing a decrease in the clay content, made them less sensitive to heat shock.

As early as 1918, Linbarger[56] discovered that silicon carbide, added to the usual graphite and clay mixture, produced ware which would stand sudden changes of temperature without cracking and spalling. In 1920, Ohman[57] patented a similar refractory made by using a carbonizing binder.

At the present time, most of the graphite melting crucibles carry silicon carbide as their principal added ingredient, whether they be clay- or carbon-bonded.

A comparatively new refractory brick, described by Diamond,[58] consists of a mixture of silicon carbide, with or without graphite, a car-

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[45] E. B. Forse, "Kiln Furniture," U. S. Pat. 1,969,126, Aug. 7, 1934.

[46] G. S. Diamond, "Properties and Performance of Silicon-Carbide Batts in Porcelain and Other Ceramic Industries," *Bull. Amer. Ceram. Soc.*, **15** [9] 297–98 (1936).

[47] Anon., "Silicon-Carbide Muffles Save Fuel," *Ceram. Ind.*, **10** [2] 165 (1928).

[48] Anon., "Advantages of New Type Kiln Construction," *ibid.*, **10** [4] 416–20 (1928).

[49] (*a*) E. P. Gillette (Gillette Research Corp.), "Gas Generator," U. S. Pat. 2,058,437, Oct. 27, 1936.

(*b*) E. P. Gillette, "Method and Apparatus for Burning Limestone and Recovering Carbon Dioxide," U. S. Pat. 2,047,064, July 7, 1936.

[50] H. R. Houchins and C. McMullen, "Silicon Carbide and Its Application in Metallurgy," *Metals & Alloys*, **3** [1] 12–14 (1932).

[51] H. E. White, "Refractories and Refractory Cements for the Nonferrous Foundry," *Jour. Amer. Ceram. Soc.*, **13** [4] 219–41 (1930).

[52] E. J. Bruderlein, "Manufacture of Silicon-Carbide Retorts," *Trans. A.I.M.M.E.*, **121,** 441 (1936).

[53] E. H. Bunce and E. C. Handwerk, "New Jersey Zinc Co. Vertical Retort Process," *ibid.*, **121,** 427 (1936).

[54] William Peirce and R. K. Waring, "New Jersey Zinc Co. Process for Refining Zinc by Redistillation," *ibid.*, **121,** 445 (1936).

[55] H. E. White, "Development of Modern Refractories," *Fuels & Fur.*, **8** [1] 107–10 (1930); *Ceram. Abs.*, **9** [10] 850 (1930).

[56] S. C. Linbarger (Carborundum Co.), "Refractory Article and Method of Making the Same," U. S. Pat. 1,277,-227, Aug. 27, 1918.

[57] J. L. Ohman, "Refractory Material," U. S. Pat. 1,356,-939, Oct. 26, 1920.

[58] G. S. Diamond, "Tercod, New Refractory Brick for Electric Furnaces," *Trans. Electrochem. Soc.*, **63,** 301–304 (1933); *Ceram. Abs.*, **12** [9] 332 (1933).

bon bond, and a protective borosilicate glaze to prevent oxidation. The physical properties of these brick compared to silica brick are tabulated in the work cited.

X. Miscellaneous Uses

Among the more recently developed uses of silicon carbide is the Fitterer C-SiC thermocouple first described by Fitterer[59] in 1933. This couple is composed of silicon carbide, in the form of a "Globar" rod, forming a junction with a graphite tube in which it is inclosed but in contact, of course, only at the hot junction. It is characterized by refractoriness and a high e.m.f. Fitterer[60] has described a number of interesting applications of this thermocouple, among them an 11-foot couple, lowered through the roof of a basic open-hearth steel furnace and immersed 10 inches into the metal through 2 or 3 inches of slag.

Silicon carbide in the form of electrical-resistance elements (which can be considered a refractory use) is being applied as a source of heat in heat-treating and similar furnaces. Temperatures up to 1500°C may be obtained, a temperature considerably higher than can be obtained with metallic resistors.[50] These nonmetallic resistors also find considerable use in laboratory-type furnaces and more recently for firing ceramic ware. Harris[61] described the operation of a kiln for firing ceramic ware that was equipped with silicon-carbide heating elements and fired to 1306°C on a closely controlled time-temperature curve. Gould[62] reported the successful use of silicon-carbide resistors in firing experimental thin high-fired ware.

XI. Bonded Silicon Carbide as Heat-Exchanging Media

The high thermal conductivity, low permeability to gases, and high physical strength at high temperatures of grade A shapes makes them superior heat exchangers, while their refractoriness makes them operative under conditions in which metallic recuperators collapse completely. Tone[63] secured a basic patent in 1922, covering a recuperator built of silicon-carbide heat-transferring walls. The accumulated engineering data and experience in design are recorded in patents issued to Fitch.[64] Fitch increased the heat-transfer rate of silicon-carbide tubes by his invention of the "corebuster," a solid fireclay cylinder that is placed lengthwise in the center of the tube. Stromberg[65] reported experiments made on commercial-size recuperators both with and without "corebusters." The results of his experiments are summarized in Table VI.

To make these tests under more controllable conditions, the secondary air was not used for combustion, so that actually there was somewhat more weight of secondary air than of flue gas. The high efficiency and the high temperature of the preheated air are worth noting in the case of test No. 1.

Read[66] has reported the results of recent operating data for silicon-carbide recuperators and special experiments made under controlled laboratory conditions. The silicon-carbide tube gave 78% greater heat transfer than did the clay.

TABLE VI

	Test No. 1 (with corebuster)	Test No. 2 (without corebuster)
Temp. of air entering recuperator (°F)	93	93
Temp. of air leaving recuperator (°F)	1275	941
Temp. of flue gases entering recuperator (°F)	2318	2354
Temp. of flue gases leaving recuperator (°F)	1027	1321
Sensible heat in flue gases entering recuperator (B.t.u./hr.)	793,000	772,000
Sensible heat recovered by secondary air that was heated (B.t.u./hr.)	416,000	288,000
Recuperator efficiency (%) (B.t.u./hr.)	52.5	37.3

The air-flow through each tube was maintained at a rate of 2400 cubic feet per hour measured at 70°F and at atmospheric pressure (see Table VII). In another test, in which the mean veloci-

[59] G. R. Fitterer, "New Thermocouple for Determination of Temperatures up to 1800°C," *Trans. A.I.M.M.E.*, **105**, 290–301 (1933).

[60] G. R. Fitterer, "Some Metallurgical Applications of the C-SiC Thermocouple," *ibid.*, **120**, 189–216 (1936).

[61] E. J. Harris and B. A. Bovée, "Some Uses of Electric Furnaces for Ceramic Firing," *Bull. Amer. Ceram. Soc.*, **14** [7] 219–22 (1935).

[62] R. E. Gould and M. G. Toole, "Progress Report on Tests of Various Electric Heating Elements for Furnace Temperatures between 1100° and 1500°C," *Trans. Electrochem. Soc.*, **70**, 89–109 (1936); see also "Preliminary Experiments for Development of Continuous Electric Ceramic Kiln for High-Temperature Firing," *ibid.*, pp. 111–30; *Ceram. Abs.*, **16** [7] 217 (1937).

[63] F. J. Tone, "Recuperator," U.S. Pat. 1,433,248, Oct. 24, 1922.

[64] (*a*) W. H. Fitch, "Continuous Heating Furnace," U. S. Pat. 1,486,369, March 11, 1924.
(*b*) W. H. Fitch, "Heating Furnace," U. S. 1,735,608, Nov. 12, 1929 (and a number of others issued to Fitch).

[65] B. W. Stromberg, "Recuperators for Super-Temperatures," *Blast Fur. Steel Plant*, **18** [3] 482–83 (1930).

[66] H. L. Read and F. L. Fritsche, "Silicon Carbide Serves as Heat-Exchange Medium," *Steel*, **96**, 39–41 (Feb. 25, 1935); *Ceram. Abs.*, **15** [4] 125 (1936).

TABLE VII

Type	B.t.u. recovery hr./tube	Av. air velocity at mean temp. (ft./sec.)	Greater recovery by type D (%)
A (bonded sillimanite)	17,600	14.5	42
B (bonded fused alumina)	18,600	15.0	35
C (bonded 70% SiC)	20,700	16.00	21
D (grade A bonded SiC)	25,000	17.5	

ties of the air flowing through the test recuperator tube was maintained at approximately the same rate, the advantages of silicon carbide in obtaining high temperatures for preheated air are indicated, the following table summarizing the test data.

TABLE VIII

Type	Av. air velocity in tube at mean temp. (ft./sec.)	Temp. rise of air passing through tube (°F)
A (bonded sillimanite)	8.8	972
B (bonded fused alumina)	7.7	1012
C (bonded 70% SiC)	8.1	1080
D (grade A bonded SiC)	8.8	1228

Read[66] describes several examples of commercial silicon-carbide recuperators, including units used in the glass industry and in metallurgical practice.

XII. Thermal Conductivity of Silicon-Carbide Refractories

The first recorded measurement of the coefficient of thermal conductivity of silicon-carbide refractories was made by Wologdine.[67] Wologdine's determinations were made at furnace temperatures that did not exceed 1000°C. He reported a value of 0.0231 "gram-cal. · sec. · sq. cm. · 1°C" as the coefficient of the thermal conductivity of silicon carbide.

Hartmann and Westmont's[68] measurements were made on walls built up of regular standard silicon-carbide brick. The general experimental arrangement was adapted from that used by Dudley.[69]

Norton[70] made measurements of the thermal conductivity on solid cylinders $4^1/_2$ inches in diameter and 9 inches long. Golla[71] made an intensive study of the thermal conductivity of refractories including bonded silicon carbide.

Measurements on bonded silicon carbide are

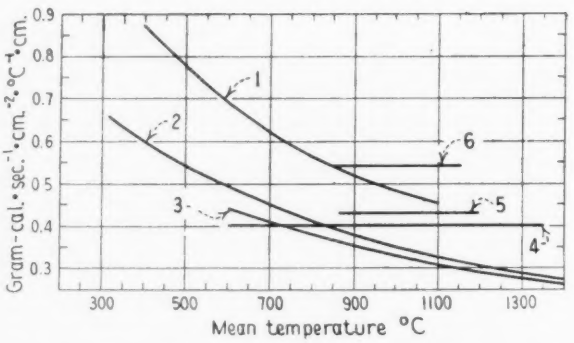


FIG. 1.—Thermal conductivity of SiC refractories (recrystallized SiC); curve No. 1, Eucken, 1932 (calculated); curve No. 2, Wilkes, 1933; curve No. 3, Norton, 1927; curves Nos. 4, 5, 6, Hartmann and Westmont, 1925.

given in the four curves plotted in Fig. 4. As may be noted, curve No. 1 is for a grade A bonded silicon-carbide refractory; curve No. 2 for grade B, while curve No. 5 is representative of a semisilicon-carbide refractory.

Golla studied different varieties of refractories, including various types of fire clay, alumina, zircon, magnesia, etc. From these data, Eucken,[72] under whom Golla and others worked on this problem, made a mathematical study of the heat conductivity of the specific components that went into the formation of different refractory bodies. His calculation for silicon carbide is given in Fig. 1, curve No. 1. The form of the descending curve is characteristic of crystalline refractories, according to Eucken. That is, states Eucken, "the mean thermal conductivity of crystalline refractory materials decreases with temperature." The reverse, he states, is true of glasses and amorphous material. As a result, we may have bonded crystalline refractories with thermal conductivities that vary from negative to positive temperature coefficients as the amount of vitrified bond is increased. Wilkes[73] came to a similar conclusion from a survey of the literature.

Wilkes' curve, for recrystallized silicon carbide is given in Fig. 1, curve No. 2. This checks Norton's fairly closely and is roughly parallel (but, of course, lower in value) to Eucken's calculated curve for solid silicon carbide. Wilkes measured the conductivity of one bonded silicon-carbide brick only. This was a commercial product but

[67] S. Wologdine and A. L. Queneau, "Conductivity, Porosity, and Gas Permeability of Refractory Materials," *Electrochem. & Met. Ind.*, **7** [9] 383 (1909).

[68] M. L. Hartmann and O. B. Westmont, "Thermal Conductivity of Carborundum Refractories," *Jour. Amer. Ceram. Soc.*, **8** [5] 259–95 (1925).

[69] Boyd Dudley, Jr., "Conductivity of Refractories," *Trans. Electrochem. Soc.*, **27**, 285–337 (1915).

[70] F. H. Norton, "Thermal Conductivity of Some Refractories," *Jour. Amer. Ceram. Soc.*, **10** [1] 30–52 (1927).

[71] H. Golla and H. Laube, "Wärmeleitfähigkeitsmessungen an Feuerfesten Materialien," *Tonind.-Ztg.*, **54** [90] 1411–14; [91] 1431–32; [93] 1458–60 (1930).

[72] A. Eucken, "Wärmeleitfähigkeit Keramischer Feuerfester Stoffe," *Forschungsheft VDI* (Soc. of German Engineers), No. 353, 1932.

[73] G. B. Wilkes, "Thermal Conductivity of Refractories," *Jour. Amer. Ceram. Soc.*, **17** [6] 173–77 (1934).

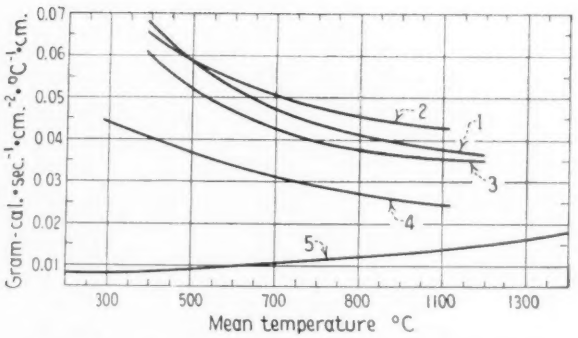


FIG. 2.—Thermal conductivity of SiC refractories (grade A bonded SiC (85% + SiC)); curves Nos. 1, 2, and 3, Holler, 1936; curve No. 4, Golla and Laube, 1930; curve No. 5, Wilkes, 1933.

unusually high in porosity. The mean conductivity values were considerably lower than those obtained by Golla, or by Holler[15] (see Fig. 2), but this may, at least in part, be accounted for by the high porosity.

The most recent work on the thermal conductivity of bonded silicon-carbide refractories was reported by Holler (a German engineer who undertook this specific problem as the subject for a doctoral thesis). The measurements were made at the Technical Institute of Aix-la-Chapelle. The method made use of a water-flow calorimeter in the form of a copper cylinder placed in the axis of the cylindrical test pieces. The heating element was molybdenum wire wound on a bonded corundum cylinder, protected from oxidation by a slowly moving stream of nitrogen.

The apparatus used by Holler was the same as that previously used at the Technical Institute[74] to determine the thermal conductivity of insulating and other refractory materials. Holler, however, had to make changes so that it could be used for silicon carbide, one of these changes providing better water circulation in the tubular copper calorimeter. Holler made his own test pieces but from grain of known composition in three forms, namely (1) run-of-mill, (2) magnetically treated, and (3) magnetically treated and alkaline washed. He secured the maximum density of grain by experiment, and followed the regular commercial procedure in mixing and molding. The drying and firing was carried out in the plant of one of the large manufacturers of silicon-carbide refractories.

[74] H. Salmang and H. Frank, "Measuring Thermal Conductivity of Refractory Materials at High Temperatures," *Sprechsaal*, **68** [15] 225–28 (1935); *Ceram. Abs.*, **14** [10] 249 (1935).

Holler reported his different test pieces in terms of the original mix, that is, according to type of grain and amount of clay bond, and the porosity of the finished fired piece. Curves Nos. 1, 2, 3, and 4 in Fig. 3 show the effect of varying the clay content. Curves Nos. 1, 2, and 3 in Fig. 2 show the effect of varying the grain by different preliminary preparations. These changes are negligible for practical purposes as far as seriously affecting the thermal conductivity values.

Because the work of Golla and Holler is the most complete as to the range of compositions of bonded silicon carbide and also as to the definite chemical and physical characteristics of these compositions, they should probably be accepted as the best data now available for the thermal conductivity of bonded silicon carbide.

Thermal conductivity is the most valuable physical property of bonded silicon-carbide refractories; therefore the chief published data have been assembled in the form of curves in Figs. 2, 3, and 4. The thermal conductivity of recrystallized silicon carbide, together with Eucken's calculated curve for solid SiC may be found in Fig. 1. In all of these curves, thermal conductivity is reported in the usual conventional way of mean coefficient of thermal conductivity for average temperatures in c.g.s. units, the basis of calculation being Fourier's law.

XIII. General Physical Properties of Silicon-Carbide Refractories

One of the most characteristic and desirable physical properties of silicon carbide from the refractory viewpoint and one that is frequently re-

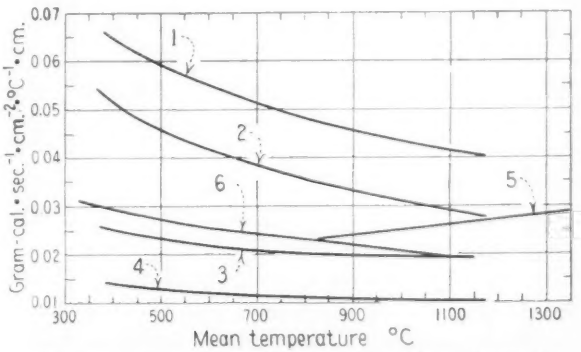


FIG. 3.—Thermal conductivity of SiC refractories with varying amounts of clay bond; curve No. 1, 5% clay, 16.16% porosity (Holler, 1936); curve No. 2, 10% clay, 17.08% porosity (Holler, 1936); curve No. 3, 20% clay, 20.53% porosity (Holler, 1936); curve No. 4, 30% clay, 26.73% porosity (Holler, 1936); curve No. 5, 31.5% bond, 20.70% porosity (Hartmann and Westmont, 1925); curve No. 6, 77.3% SiC, 21% porosity (Golla and Laube, 1930).

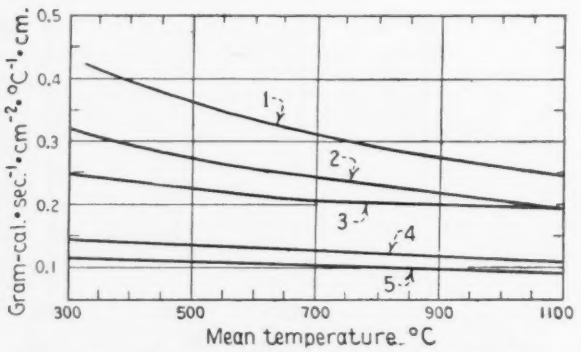


FIG. 4.—Thermal conductivity of SiC refractories with varying amounts of SiC; curve No. 1, 89.7% SiC, 25.6 porosity (Golla and Laube, 1930); curve No. 2, 77.3% SiC, 21% porosity (Golla and Laube, 1930); curve No. 3, 20% clay, 20.53% porosity (Holler, 1936); curve No. 4, 57.2% SiC, 24.5% porosity (Golla and Laube, 1930); curve No. 5, 49.4% SiC, 22.1% porosity (Golla and Laube, 1930).

ferred to in the literature is its high emissivity. While from qualitative experience and direct observation the fact that this emissivity must have a high value has been frequently confirmed, its actual value in terms of the emissivity constant applicable to the formal statement of the Stefan-Boltzmann law has apparently not been determined. The only data published were given by Linbarger[75] in 1918. According to his series of curves, the emissivity of bonded silicon carbide is much higher than that for chromite or magnesite brick, and twice as great as for fireclay brick at temperatures of 200°C and higher. It is evident, however, that emissivity data on different types of silicon-carbide and other refractories are needed.

Hartmann,[76] in 1920, reported electrical-resistance measurements for a number of special refractories, including recrystallized and bonded silicon carbide. His measurements were made under reducing conditions over a temperature range up to 1500°C. Recrystallized silicon carbide has a low electrical resistivity (106.0 ohms per cm.^{3}) at room temperatures, but this decreases rapidly with temperature so that at 1500°C it is only 1.62 ohms per cubic centimeter. Bonded silicon carbide, on account of its ceramic bond, has a much lower but measurable electrical resistivity at room temperature than recrystallized silicon carbide, but with increase of temperature it also conducts more electrical current. The specific resistance of bonded silicon carbide varies with different compositions but in any case is a factor to consider in the design and operation of electrical furnaces. White[77] made a further study of the electrical resistivity of refractories in 1932, using the same general procedure as Hartmann, but under oxidizing conditions.

The thermal expansion of bonded silicon carbide has been measured by a number of methods, and the various values for comparable material agree reasonably well. Hougen[78] reported the mean linear coefficient of bonded silicon carbide to be 4.7×10^{-6} for the temperature interval 100° to 900°C.

Houldsworth[79] studied the effect of reheating silicon-carbide brick to different temperatures with the following results:

TABLE IX

Coeff. of linear expansions (Temp. range 15° to 1000°C.) Heat treatment	Linear expansion
Cone 9	4.71×10^{-6}
" 14	4.78×10^{-6}
" 20	3.86×10^{-6}

Norton[80] determined the linear expansion of a large number of refractories with a gas-fired furnace. He used bars one inch square and nine inches long, cut from commercial brick for test pieces, and made his measurements by means of a pair of telescopes provided with filar-micrometer eyepieces. His curve indicates that the linear expansion of silicon carbide is practically a straight-line function of temperature up to 1700°C, having approximately the value 4.3×10^{-6}. He stated that there was no shrinkage up to 1700°C.

Heindl[81] reported the expansion of different refractories up to 1800°C, on the original run and after being heated to 1800°C. He used a high-frequency induction-type electrical furnace and measured the expansion by means of an Ames micrometer dial. His curves for silicon carbide show a somewhat lower value after heating to

[75] S. C. Linbarger, "Carborundum Refractories," *Chem. Met. Eng.*, **19** [6d] 489–91 (1918).

[76] M. L. Hartmann, A. P. Sullivan, and D. E. Allen, "Physical Characteristics of Specialized Refractories: III, Electrical Resistivity at High Temperatures," *Trans. Electrochem. Soc.*, **38**, 279–300 (1920).

[77] H. E. White, "Electrical Resistivity of Specialized Refractories," *Jour. Amer. Ceram. Soc.*, **15** [11] 598–610 (1932).

[78] O. A. Hougen, "Selection Factors in Choosing Refractories for Industrial Plant Use," *Chem. Met. Eng.*, **30** [19] 737–47 (1924).

[79] H. S. Houldsworth and J. W. Cobb, "Reversible Thermal Expansion of Refractory Materials," *Jour. Amer. Ceram. Soc.*, **6** [6] 645–62 (1923).

[80] F. H. Norton, "Thermal Expansion of Refractories," *Jour. Amer. Ceram. Soc.*, **8** [12] 799–815 (1925).

[81] R. A. Heindl, "Thermal Expansion of Refractories to 1800°C," *Bur. Stand. Jour. Research*, **10** [6] 715–35 (1933); *Ceram. Abs.*, **12** [9] 330 (1933).

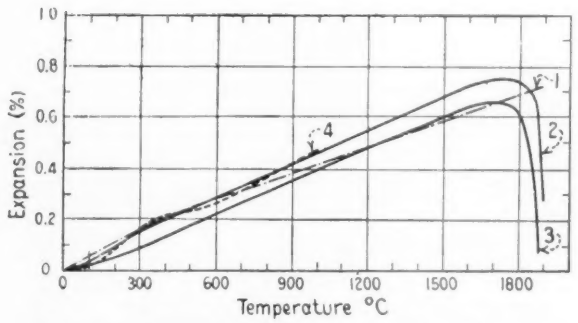


FIG. 5.—Thermal expansion of SiC refractories: grade A (85% + SiC); curve No. 1 (Norton, 1925); curves Nos. 2 and 3 (Heindl, 1933); curve No. 4, X-ray method for SiC powder (Büssem, 1935).

1800°C, doubtless caused by increased vitrification of the bond. This corroborates Houldsworth's observations, who indicated, however, that there is no change in value up to at least cone 14. Büssem,[82] working with powdered SiC crystals, made a number of expansion measurements from back reflection X-ray diffraction photographs taken at intervals of 200° up to 1000°C. His figures agree quite well with those made by the usual methods. Figure 5 shows a curve plotted from Büssem's data, and the curves of Norton and Heindl are also given, all in terms of percentage linear expansion.

In the trade literature, the linear thermal expansion of silicon-carbide brick is generally shown as a straight-line curve up to 1400°C having a coefficient of expansion of 5×10^{-6}. In view of the evidence of the technical literature, this is a conservative figure and may be safely used in furnace design.

Silicon-carbide refractories are generally described as being very resistant to spalling, but there are few published figures indicating the degree of spalling resistance. Hartmann[83] made an extensive test of the spalling losses of twelve different kinds of refractory brick. Three types of bonded silicon-carbide brick varied in spalling loss from 0.3 to 8% after ten spalls, surpassing any other type tested including several varieties of clay brick. Wilson[84] made similar tests on a number of brick, including recrystallized silicon carbide, which was the only one of nine types that showed no loss in ten spalls, the conventional number of cycles.

There is little to be found published concerning high-temperature load tests on silicon carbide, chiefly because there is no deformation up to the maximum temperature (1500°C) and loads (25 lb. per sq. in.) conventionally used for these tests. The load-test curve for grade A silicon-carbide refractories does not differ radically from the linear-expansion curve. Wilson[84] states that

"'Refrax' brick, made by recrystallizing silicon-carbide brick in the electric furnace, is another example of the crystalline-bonded structure which will withstand loads at high temperatures up to the point of dissociation."

In the following appendix, the pertinent physical and chemical properties of different types of silicon-carbide refractories are tabulated.

Appendix

(1) Physical Properties of Grade A Bonded Silicon-Carbide Refractories.*

This class is composed of bonded silicon-carbide refractories containing a minimum by weight of 85% SiC in the finished product.

	Composition (%)
SiC	85.0–90.0+
SiO_2	6.7–8.8
Al_2O_3	2.4–4.2
Fe_2O_3	0.3–0.95
CaO	nil–0.3
Bulk density	2.22–2.55
Porosity (%)	13.4–28.3
P.C.E. cone 39	
Coeff. of expansion 25°–1400°C	0.000005 per °C

Spalling Test: No loss up to 10 coolings in conventional test, but manufacturers claim that test has been continued to 100 air quenches without loss.

High Temperature Load Test: No deformation up to 1500°C with 50 lb. per sq. in. load.

Specific Heat: 0.186–0.235.

Average cross-breaking strength		
Modulus of rupture at	20°C	2100 lb./in.²
" " " "	1350°C	900 " "

* As compiled from published data in references cited.

THERMAL CONDUCTIVITY†

Mean temp. (°C)	Gram. cal. · sec.⁻¹ · °C · cm.⁻² · cm.	B.t.u. · hr.⁻¹ · °F · ft.⁻² · in.	Mean temp. (°F)
500	0.0367–0.0585	106.3–169.7	932
700	.0312– .0507	90.5–147.0	1292
800	.0287– .0477	83.3–138.0	1472
900	.0268– .0453	77.7–131.5	1652
1000	.0255– .0434	74.0–125.8	1832
1100	.0244– .0420	70.7–121.8	2012

† Data compiled from the work of Golla and Laube and from Holler. The average weight of grade A SiC brick, standard 9 by $4\frac{1}{2}$ by $2\frac{1}{2}$ in. is $9\frac{1}{4}$ lb., and they are manufactured in the complete 9-in. series as well as in special shapes.

[82] W. Büssem, "Expansion Measurements of Crystalline Bodies by X-Ray Method: I," *Ber. Deut. Keram. Ges.*, **16** [8] 381–92 (1935); *Ceram. Abs.*, **15** [3] 107 (1936).

[83] M. L. Hartmann and O. A. Hougen, "Physical Characteristics of Specialized Refractories," *Trans. Electrochem. Soc.*, **37**, 707–15 (1920).

[84] Hewitt Wilson, C. E. Sims, F. W. Schroeder, "Artificial Sillimanite as a Refractory: II," *Jour. Amer. Ceram. Soc.*, **7** [12] 907–19 (1924).

(2) Grade B and Semisilicon-Carbide Refractories

The grade B bonded silicon-carbide refractories may be described as those that contain between 73 ± 5% SiC by weight in the finished product.

The semisilicon-carbide refractories may be described as those that contain 50% or less by weight of SiC in the finished product.

The physical properties of grade B and semisilicon carbide vary with the bonding media and processes of manufacture, and specific physical properties must be obtained from the manufacturer.

(3) Recrystallized Silicon-Carbide Refractories

Recrystallized silicon-carbide composition

SiC	96.9%
SiO_2	0.7
Al_2O_3	1.3%
Fe_2O_3	1.3

Bulk density 2.06–2.20
Porosity (%) 34.4–35.3
Coeff. of expansion 0.000005/°C up to 1400°C
No deformation in load test up to 1700°C (maximum temperature reached in test)
Modulus of rupture at 1350°C 2437 lb./sq. in.

Thermal Conductivity

Mean temp. (°C)	Gram.-cal.-- sec.$^{-1}$·°C·cm.$^{-1}$·cm.	Mean temp. (°F)	B.t.u.-- hr.$^{-1}$·°F·ft.$^{-1}$·in.
600	0.040–0.049	1112	116–142
1000	.033–0.043	1832	96–125
1300	.027–0.040	2372	78–116

CARBORUNDUM COMPANY
RESEARCH LABORATORIES
NIAGARA FALLS, NEW YORK

A DISCUSSION OF THE PROPERTIES OF MORTAR FOR USE IN UNIT MASONRY CONSTRUCTION*

BY LEE S. TRAINOR

ABSTRACT

A table of mortar properties is presented and the function of each is discussed with relation to its effect on obtaining strong, durable, water-tight masonry. Reference is made to the physical properties of masonry units and their importance in obtaining good masonry. Recommendations are presented covering the proper selection and use both of mortar and units for the production of sound, water-tight walls.

I. Introduction

The ever-increasing number of reports of leaky walls in unit masonry construction has emphasized the need for further information regarding the cause of this condition. Much data and information are now available, and its successful application depends largely upon a thorough understanding of the wide diversity of properties both of building units and mortars and their mutual suitability. Other factors include design, especially the tendency toward the use of thin walls with more freely exposed masonry, and the ever-important factor of workmanship.

A leaky wall usually is one with unfilled joints or open spaces where brick and mortar apparently meet but are not attached. The formation of such openings is influenced by the properties of the materials used and class of workmanship employed. A wet interior is one symptom of a leaky wall; repeated and prolonged efflorescence on the exterior of the wall is another. The condition, however, may exist without these symptoms.

The fact that openings exist is proved by the many instances of leaky walls wherein both units and mortars are comparatively impervious. Water follows the path of least resistance, *i.e.*, through the openings between the masonry materials and not through these materials.

Water that enters pores and voids of brick, stones, mortars, etc., readily evaporates from the exterior surface. This is a normal condition offering no cause for concern.

Assuming proper design, adequate inspection during construction, and good workmanship, the most important factor in obtaining a water-tight wall is the selection and use of a mortar properly adapted to the units, taking into consideration the nature and severity of exposure.

Lime promotes mortar adaptability,* and a mortar rich in lime is suitable for all types of units. An adaptable mortar is first of all workable. It has bonding power. It is characterized by low-volume changes subsequent to hardening. It has good extensibility, produces good masonry strength, and has a rate of hardening compatible with modern methods of construction. These properties will be discussed in the light of the results of research in the masonry field.

II. Discussion of Completed Research

A quantitative study of the simple facts leads to some new concepts involving the use of new terms. These will be considered in detail.

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 23, 1937 (Structural Clay Products Division).

(1) Mortars

(A) List of Properties	Factors Controlling
(1) Workability	(*a*) Water-retaining capacity (*b*) Bulk density (weight/cu. ft. freshly mixed mortar) (*c*) Plasticity (troweling properties)
(2) Adhesiveness of Bonding Power	(*a*) Water-retaining capacity (*b*) Plasticity (*c*) Composition capable of forming bond layer
(3) Adaptability	(*a*) Water-retaining capacity (*b*) Plasticity (*c*) Low volume changes subsequent to hardening (*d*) Fair amount of strength
(4) Bonding Efficiency*	(*a*) Composition capable of forming bond layer (*b*) Water-retaining capacity (*c*) Low volume changes subsequent to hardening (*d*) Plasticity (*e*) Strength (*f*) Extensibility
(5) Extensibility	(*a*) Strength (*b*) Elasticity
(6) Contribution to Efflorescence	(*a*) Contribution to dryness of walls (*b*) Soluble materials in mortar
(7) Weather Resistance	(*a*) Contribution of mortar (through its properties) to dryness of walls (*b*) Strength (*c*) Surface permeability, particularly change in this property with time (*d*) Ability to "heal" cracks in mortar (caused by wall settlement or otherwise) called "autogenous healing"; caused by ability to form bond layer
(8) Masonry Strength	Composite of (*a*) Bonding efficiency (*b*) Strength (particularly strength in flexure)

* Bonding efficiency is a composite of all of the essential mortar properties.

(2) Meaning of Terms

(*1*) *Water-Retaining Capacity:* The property of retaining or holding the mixing water. A mortar deficient in this property segregates when left uncovered on a base having little or no suction, and it is quickly sucked dry and stiffens on a porous base.

(*2*) *Compacting on a Porous Base:* A disastrous type of volume change. It occurs prior to any hardening of the mortar through cementing action. In cross-joints (vertical joints) it draws the mortar away from the unit. It occurs in less than a minute after the mortar is placed. It is caused by rapid water loss to a building unit that has suction. The mortar occupies less volume after it has lost its water. Use mortar of high water-retaining capacity and avoid open joints. Compacting is caused by a physical change—water loss.

(*3*) *Hardening:* Hardening is not stiffening due to water loss; it is not gain in strength. Hardening is the increase in resistance to penetration by a solid rod or other object of small diameter. It is caused by chemical changes, "cementing action."

(*4*) *Shrinkage During Early Hardening:* This is the diminution in volume that a mortar undergoes during the first day or two subsequent to any compacting which the mortar may have initially undergone. It has been demonstrated that this type of volume change is not responsible for open joints in masonry. As this type of volume change proceeds, the mortar hardens, adheres to the unit, and "draws itself in," the plastic, freshly laid mortar being drawn into the slowly hardening joints below.

(*5*) *Volume Changes Subsequent to Hardening:* This is the most damaging of the three distinct types of volume changes. It consists of expansion and shrinkage occurring alternately and over a period of many years. All mortars except those containing lime and sand alone tend to undergo volume changes of this kind to an appreciable extent. Wetting causes cement particles to expand and on drying out again they shrink. This is a common cause of cracks in concrete floors, sidewalks, roads, and retaining walls. These volume changes create stresses. The rigid mortar can not flow or yield sufficiently and quickly. The mortar cracks or comes loose from the building unit.

(*6*) *Bond:* At the plane where brick and mortar meet, the two materials may or may not become attached, depending mainly on the mortar; usually they become attached in spots. The condition (adhesion of mortar to unit) is called bond.

(*7*) *Extent of Bond:* If the mortar adheres at all points where brick and mortar meet, the extent of bond is complete; otherwise it is poor. Poor extent of bond is characteristic of mortars of high strength and low water-retaining capacity. Thus strong mortars often produce weak walls. Volume changes subsequent to hardening destroy (tear loose) a bond that is poor in extent, which causes "mortar pancakes." The mortar pancakes have high strength, but that strength is

not imparted to the wall. They also have low porosity. The wall is easily saturated. The mortar pancakes are highly resistant to freezing and thawing. They have to be raked out and replaced by mortars that provide a good extent of bond, thereby giving a more water-tight wall. Frost resistance in a wet wall is a "frozen asset." Frost resistance in a comparatively dry wall is more or less superfluous.

(*8*) *Bonding Efficiency:* The percentage or fraction of the mortar strength that is available for producing bond strength is the bonding efficiency. When two brick with an intervening mortar joint are pulled apart, three things can happen, (1) the mortar will separate completely from the brick, (2) it will fail within the joint, leaving both brick covered with mortar, or (3) it will fail partially at the plane where brick and mortar meet, as well as within the joint. From the standpoint of wall strength, the bonding efficiency of a mortar should be such that 50% or more of the failure will be within the mortar joint. In other words the bond must be at least as strong as the mortar. High strength in mortar that produces low bond strength is superfluous and not available for producing masonry strength.

(*9*) *Plasticity:* This is poorly understood. If a plastic mortar is spread on a very rough surface, it tends to fill all crevices of that surface completely, whereas a less plastic mortar tends to "bridge across" the interstices. Again, a bed of plastic mortar slumps into and fills any partially filled vertical joints which, with a less plastic mortar, would be bridged across. This is without regard to water-retaining capacity. The latter property tends to preserve plasticity during the time of the mason's operations. A mortar of high water-retaining capacity is invariably a plastic mortar but, further than this, it is one that tends to remain plastic on a porous base during the time that the mason works with it.

(*10*) *Extensibility:* The amount of stretching that a hardened mortar can undergo before it breaks is its extensibility. If a hardened Portland cement mortar can be stretched without breaking only $^1/_{50}$ inch per 100 inches (linear) and shrinks on drying $^1/_{10}$ inch per 100 inches, something happens; the mortar either cracks badly (if the extent of bond is good) or it is torn loose from the brick (the extent of bond being poor). Its factor of safety is $^1/_5$, *i.e.*, $^1/_{50}$ divided by $^1/_{10}$. Mortars containing 2 volumes of lime to 1 of cement, and mortars richer than this in lime, have factors of safety of 1 or greater. This is the reason they remain bonded for centuries. Mortars of these compositions have good extensibility and low volume changes subsequent to hardening, a necessary combination.

Any mortar mix for unit masonry which does not contain lime in quantity at least equal in volume to that of the cement is a misuse of lime. The most necessary properties, *i.e.*, workability, adhesiveness, bonding efficiency, adaptability, and low volume changes subsequent to hardening, are not obtained to the desired extent with a mixture containing less lime than that in a 2 lime to 1 cement mix.

(*11*) *Adaptability:* An adaptable mortar is one that produces a good extent of bond with all types of brick or other building units without involving any necessity for wetting the building units before laying them. As the amount of lime beyond that in a 1:1:6 mix is increased, the mortar becomes more and more adaptable. A straight lime-putty mortar is the most adaptable of all mortars; adaptable mortars have high water-retaining capacity and high bonding efficiency.

(*12*) *Bond Layer:* At the plane where brick and rich-in-lime mortar meet, a hard, dense crystal layer is formed. The exact composition of this layer has not been determined, but it is known that the chemical element, calcium (supplied by all limes) is invariably present in it. Because of the formation of this bond layer, it is impossible to determine the bond strength of lime mortar, since the bond strength in this case is much greater than the strength of the mortar. This condition provides the highest possible degree of bonding efficiency. Any cracks that occur in mortar capable of forming a bond layer are soon healed, much as a broken bone is healed.

(*13*) *Adhesiveness or Bonding Power:* The term "adhesiveness" is self-explanatory. It is preferable to use the term "bonding power," which in some cases is indicated by bonding efficiency. A mortar that does not adhere at all has zero bonding power and zero bonding efficiency. A mortar with bonding power such that its bond strength exceeds its own tensile strength has the highest possible bonding efficiency. Bonding efficiency is the ratio of bond strength to tensile strength of mortar. Since it is impossible, however, actually to measure the bond strength of a mortar that breaks within the joint and not

at the plane where brick and mortar meet, bonding efficiency in such cases can only be inaccurately estimated and considered as some value greater than the ratio of tensile strength of brick-mortar specimen to tensile strength of mortar specimen.

A mortar of a given strength which is so adhesive that its bond strength is greater than its tensile strength has the highest possible bonding efficiency but not necessarily the highest degree of bonding power. This fact serves to differentiate between the meaning of the two terms, bonding efficiency and bonding power. From the standpoint of masonry strength, bond strength in excess of mortar strength may be superfluous. From the standpoint of water-tightness and bond durability, this is not the case. Bonding power, as considered in this light, can never be too high.

Bonding power is determined by the ability of a mortar to form a bond layer at the plane where brick and mortar meet.

III. Current Research

Probably the outstanding current research on this subject is the work at the Massachusetts Institute of Technology under the direction of Walter C. Voss. Some of the outstanding indications shown by this work are as follows:

(1) Brick and mortar characteristics, considered separately, will yield no criterion for permeable bond.

(2) All brick will not react favorably with all mortars, but must be studied to find their proper complementary mortar.

(3) Uniformity of brick structure is indispensable in selecting a mortar for use with the brick.

(4) It is absolutely essential that a brick possess from 5 to 10% total absorption by immersion for 48 hours, and that its rate after the first 5 to 10 minutes be uniform and gradual for several hours.

(5) Absorption tests are far more reliable in deciding the desirability of a brick for external use than any strength tests now used.

(6) Mechanical bonds produced by wire-cutting, frogs, etc., do not materially affect the tensile bond strength or the final bond layer.

(7) Excessive density (weight per unit volume) in a mortar is just as objectionable as it is in a brick.

(8) Cement and lime are equally important constituents of a good mortar; neither may be omitted where all of the usual conditions of exposure and construction exist.

(9) Highly absorbent brick require mortars with high lime content, whereas brick with reasonable lower percentages of absorption (about 5%) may well have the lime content reduced to not less than equal parts of lime and cement by volume.

(10) Extremely dense brick, or brick, which have high differential shrinkages with respect to the mortars used and which present a difficult problem, must be laid in high lime-content mortars to afford as much protection and plastic contact as possible, going perhaps to a straight, lime-sand mortar.

(11) Loaded walls are more water-tight than curtain walls; intimate contact is thus advantageous.

(12) Thin joints are more effective than thick joints.

It is interesting to note that the following hypothesis presented by Professor Voss in 1933 still stands.

A leakless brick-masonry wall may be produced by an assemblage of brick and mortar where (1) the relation of the absorptive power of the brick to the amount of water in the mortar is such that the initial movement toward the brick plane sets in early and continues at an even rate for several hours; and (2) where the mortar is so constituted as to permit such loss of water and still provide a soluble product which in the process is concentrated at the brick plane and is available thereafter for a long period of time to form a compound with a minimum of differential shrinkage with the brick, the assemblage being capable by its porous structure to permit repetition of such action.

The composition of the "bond layer" presents many difficult petrographic and crystallographic problems. Study so far directed toward this end seems to indicate that this layer, regardless of the mortar mix, is a compound which we may call "*X*." The possibilities are that this compound, "*X*," contains calcium; furthermore, the likelihood of this calcium being in the form of a hydroxyl or carbonate is stronger than that of its being a silicate. Further study is being conducted to determine definitely, if possible, the exact composition of the compound, *X*.

IV. Conclusions

After taking all related factors into consideration it is generally agreed that masonry mortar should possess these five essential qualities:

(1) High water-retaining capacity. This means the ability of the mortar to hold enough water to remain plastic under the trowel regardless of the absorption of the masonry unit. Only such a mortar will have good workability and facilitate filling of joints, especially the verticals.

(2) Bonding power or adhesiveness. This is more important than mere mortar strength, for if a mortar does not bond to the masonry it adds no strength to the wall. Some of the strongest mortars have the poorest bonding power and may produce a weaker masonry structure than a weaker mortar that bonds well. This is not always recognized in building codes.

(3) Low volume changes subsequent to hardening. Shrinkage occurs to some degree in all types of mortar, not only when they take their initial set but, in some cases, by chemical action that continues over a long period of time. To this shrinkage is attributed most of the separation cracking that causes wet or leaking walls. Straight Portland cement mortars, for example, shrink considerably over a long period of years and to a greater degree than a cement and lime mortar.

(4) Reasonable strength (see bonding power). Where building codes demand specified strength and a fixed factor of safety, strength may control selection.

(5) Minimum water-soluble salts. The presence of water-soluble salts in mortar or masonry will not in itself cause efflorescence. Dampness must also be present. But the amount and nature of the efflorescence that may develop under wet wall conditions is related to the quantity of soluble salts put into the wall with the mortar.

Lime is an important element in producing these desirable properties.

The selection of adaptable mortars involves some sacrifice in mortar strength, without necessarily sacrificing masonry strength. Often the latter is increased. Usually, the greater the sacrifice in mortar strength, the more enhanced are the properties, low volume changes after hardening, high water-retaining capacity, workability, and adhesiveness. With continued sacrifice of mortar strength, the point is reached where the masonry strength is reduced.

For all ordinary brickwork, the masonry strength obtained with a mortar made with 2 volumes of lime (dry hydrate or stiff putty) to each volume of Portland cement and 9 volumes of sand is eminently satisfactory. If greater masonry strength is desired, it is preferable to reduce the amount of sand from 9 to 7 or 8 volumes retaining the 2:1 volume proportion, lime to cement. A 2 lime to 1 Portland cement to 9 sand mortar hardens quickly enough to meet all demands of modern construction. It is far more workable and adaptable than the 1:1:6 mix, which is preferred for brickwork below grade. The use of the 2:1:9 mortar mixture or any other mortar having the same properties will go far toward providing water-tight walls.

National Lime Association
Washington, D. C.

RESULTS FROM THE USE OF PLASTICIZED SULFUR AS A JOINTING MATERIAL FOR CLAY PRODUCTS*

By W. W. Duecker† and H. Z. Schofield‡

Abstract

The application of two types of plasticized sulfur in the construction of a brick pavement is described. These compounds after being in service for a year show no signs of exuding. One of the compounds possesses an objectionable odor; the other may be satisfactory for use in road construction.

I. Introduction

In a paper entitled, "Plasticized Sulfur as a Jointing Material for Clay Products,"[1] in which the characteristics of plasticized sulfur were described, it was stated that, in coöperation with the Ohio State Highway Department, two types of plasticized sulfur, together with eleven other materials listed in Table I, were to be used in the construction of a test road. This test road, certain structural details of which are given in Table II, was built in the conventional manner as part of Ohio route 31, halfway between Lancaster and Logan in Hocking County. A concrete base was placed on an earthen fill. On the concrete base was put a mastic cushion on which were placed the paving brick. After the brick had been leveled off with a power roller, they were sprayed with a solution designed to prevent the adhesion of the jointing material to the top surface of the brick. The hot, molten, fluid jointing material was then poured on to the surface of the brick and allowed to penetrate all spaces between the brick. The excess material on the surface of the brick was then removed with steel scrapers.

Table I

Road Jointing Materials

Ohio highway asphalt (filler F-1): semi-asphaltic base; softening point not less than 75°C; penetration 30 to 45
Asphaltic base asphalt: softening point not less than 75°C; penetration 30 to 45
Semi-asphaltic base asphalt: softening point, 85° to 96°C; penetration 25 to 35
Asphaltic base asphalt: softening point, 85° to 96°C; penetration 25 to 35
Semi-asphaltic base asphalt 65%, asphaltic base asphalt 35%
Semi-asphaltic base asphalt 65%, asphaltic base asphalt 35% + 25% fine mineral aggregate
Ohio highway asphalt (filler F-1), 60% and 40% (by vol.) of 30-mesh sand
Natural lake asphalt containing 20 to 32% naturally incorporated inorganic material
Special pitch filler + 5% asbestos
One part Portland cement, 4 parts sand (by vol.)
One part Portland cement, 2 parts asphalt emulsion, 3 parts sand (by vol.)
Plasticized sulfur A
Plasticized sulfur B

The present paper is concerned with the application of plasticized sulfurs to this test road and describes their appearance after a year of service.

Two kinds of plasticized sulfur were employed in the construction of the experimental road. One of these products, designated plasticized sulfur A, has been described.[1] It consisted of sulfur plasticized with 10% of an olefine polysulfide and contained 30% by weight of a graded aggregate. The other material, designated plasticized sulfur B and described in Table III, was sulfur plasticized by the addition of 60% by weight of air-blown asphalt.

Table II

Details on Construction of Brick Road

Location	Ohio State Highway 31 from Fairfield County–Hocking County line and extending one and one-quarter miles into Hocking County
Concrete base	
Width	20 ft.
Depth	6 in.
Side curbs	9 in. flush
Center curb	6 in. flush
Concrete mix	1–6½
Mastic cushion	94% sand 6% asphalt cutback (by vol.)
Brick	Non-deaired, 3 in., wire-cut, vertical fiber, with side and end lugs
Length of each experimental section	300 to 450 ft.
Width of each experimental section	20 ft.

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 24, 1937 (Structural Clay Products Division). Received March 30, 1937.

† Senior Industrial Fellow, Mellon Institute of Industrial Research, Pittsburgh, Pa.

‡ Director, Research Bureau of National Paving Brick Association.

[1] W. C. Rueckel and W. W. Duecker, "Plasticized Sulfur as a Jointing Material for Clay Products," *Bull. Amer. Ceram. Soc.*, **14** [10] 329–32 (1935).

II. Application of Plasticized Sulfur A

Previous experience indicated that some difficulty might be found in melting plasticized sulfur A at the site of construction in the regular direct-fired melting equipment, because the temperature in such melting equipment cannot be definitely controlled and because plasticized sulfur A decomposes at temperatures above 180°C (350°F). To prevent such decomposition as much as possible, plasticized sulfur A was furnished in two parts. The first consisted of sulfur combined with an aggregate and the second of sulfur combined with the plasticizer. The sulfur-aggregate mixture was melted over a coal fire in the regular 450-gallon asphalt melting kettles. To this molten mass was then added the required amount of sulfur combined with the plasticizer. The heat of the molten sulfur carried the plasticizer into solution without decomposition. Although this method serves very well, it is not altogether satisfactory, owing to the fact that some over-heating cannot be avoided.

When applied to the brick pavement, the molten plasticized sulfur A proved to be superior to other materials in that it filled the spaces between the bricks more satisfactorily. This result is no doubt attributable to its low viscosity and to the fact that its high specific heat and low heat conductivity allow it to remain fluid longer. The high specific gravity of the material aided its penetration. Brick removed from the finished pavement showed that the material had filled all joints completely.

The removal of the excess of plasticized sulfur A from the surface of the brick is slightly more difficult than the removal of surplus asphalt. This is not caused by the adherence of the sulfur to the upper surface of the brick (such adhesion was prevented by the presence of a thin film of an oil-in-water emulsion), but to the fact that the plasticized sulfur is difficult to cut at the joints. Asphalt, on cooling, changes gradually from a fluid to a plastic mass. Plasticized sulfur A, on cooling, passes rapidly through a sticky stage and then becomes a rather hard plastic. This sudden hardening makes its removal rather difficult in contrast with asphalt, the joints of which can be cut rather easily. In spite of this difference, it is probable that, with experience, the plasticized sulfur A can be removed as rapidly as asphalt. It is suggested that perhaps this defect can be remedied by modifying the plasticity of the sulfur.

III. Application of Plasticized Sulfur B

Plasticized sulfur B can be melted and applied in the same manner in which asphalt is used. This material, however, is susceptible to decomposition by heat and hence temperatures above 214°C must be avoided. The material filled the joints well, probably better than asphalt, because of its greater density and higher specific heat. It bonded well with brick and the excess material could be easily removed from the surface of the brick.

IV. Results with Plasticized Sulfur A

The discernible advantages of plasticized sulfur A are that it forms a tenacious bond with the brick and completely fills all joints in the pavement flush with the upper surface of the brick. This latter characteristic is important for it is anticipated that the plasticized sulfur will protect the edges of the brick and prevent their deterioration under traffic. Three brick, jointed together on their 8 by 4-inch faces with $^1/_8$ inch of plasticized sulfur A at room temperature, had a strength of 250 pounds per square inch. After being exposed in water at 90°C for 1 hour, the joints still had a strength of 150 pounds per square inch. This fact does not indicate that the joint failed because water entered the bond. It merely reveals the strength of the material at this upper temperature, for the failure took place in the jointing material and not at the juncture. The recognizable disadvantages of plasticized sulfur A are the difficulty in removing the surplus material from the surface of the pavement and, at elevated temperatures, its obnoxious odor. The first objection may perhaps be overcome. As plasticized sulfur A is quite fluid at pouring temperature, it may be possible to reduce the width of the joints between the brick and thus to decrease the effort required to cut such joints.

Both of these compounds have now been in service for more than a year. During this time they were exposed to the cold winter of 1935–36 and the hot summer of 1936. The temperature of the brick surface at one time reached 121°F and the temperature of the subgrade, 30 inches below the surface of the pavement, extended from a minimum temperature of 28°F to a maximum of 82°F.

FIG. 1.—Appearance of pavement jointed with plasticized sulfur A after one year of service.

These severe temperature fluctuations proved the merits of the plasticized sulfurs.

Plasticized sulfur A, at the end of more than a year's exposure test (see Fig. 1), resembles hard leather in consistency. With the exception of an area comprising about 10% of the total, the filler section is in excellent condition and seems unchanged. This excepted area contains filler which was damaged by overheating in the melting kettle. Under summer temperatures the damaged filler exuded a small amount of oil (a product of the breaking down of the olefine polysulfide plasticizer because of overheating) and the filler appears lifeless.

Plasticized sulfur A is entirely different from the filler materials ordinarily used in the construction of highways; indeed, it represents the application of an entirely new material. It is a plastic material in that it can be deformed under pressure; it is semisolid owing to its aggregate content and hence supports the edges of the brick. It was evolved to approximate the characteristics of an ideal jointing material, conceived to be sufficiently plastic to allow movements in the roadway, yet sufficiently rigid to permit one to regard the entire roadway as a solid structure. It has been demonstrated that this material does not exude, that it fills the joints well, and that it is resistant to pounding traffic. It has withstood the widely fluctuating temperatures encountered. It possesses a light yellow color that makes a pleasing contrast with the dark colored brick. It has, however, a serious drawback, namely, that it emits a rather objectionable odor. This malodor no doubt is caused by sulfides.

TABLE III

SPECIFICATIONS MET BY PLASTICIZED SULFUR B

Penetration, 0°C, 200 g., 60 sec.	Not less than 20
" 25°C, 100 g., 5 sec.	28 to 34
" 46°C, 50 g., 5 sec.	Not more than 81
Specific gravity 25°C/25°C	Not less than 1.20
Flash point (Cleveland open cup) °C	Not less than 200
Softening point (ring and ball) °C	65 to 75
Loss at 163°C, 50 g., 5 hr. (%)	Not more than 1.40
Solubility in CS_2 (%)	Not less than 99.0
Proportion of sulfur by weight (%)	38 to 42

A small quantity of oil is seen to exude from the joints of that section of road laid with overheated material. This oil without question is a decomposition product. The compound has been spread by traffic over the surface of the brick and it is therefore difficult to determine whether the odor occurs in all parts of the road. It is conceded that although the compound, as prepared at present, possesses many desirable characteristics, it probably cannot be used in general highway construction unless the melting is performed under control in special equipment and its application is accompanied with care.

V. Results with Plasticized Sulfur B

Plasticized sulfur B, which consists approximately of 60% asphalt, 40% sulfur, has given

FIG. 2.—Appearance of pavement jointed with plasticized sulfur B after one year of service.

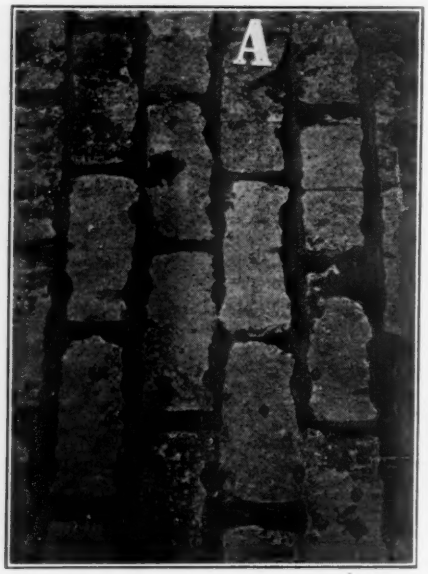


FIG. 3.—Appearance of pavement jointed with Ohio highway filler F-1 after one year of service.

very satisfactory service. This material does not suffer from the limitations noted for plasticized sulfur A. Its odor is no different from that of ordinary asphalt; it can be melted in the equipment generally available and can be handled exactly in the same manner as ordinary asphaltic compounds. In physical appearance, the filler resembles a straight asphalt filler. The section in Fig. 2 shows no evidence of exuding or receding and is considered fully satisfactory.

VI. Conclusions

It has been demonstrated that the application of plasticized sulfur to the construction of brick pavements is practical. Plasticized sulfur A bonds well to brick; it fills all joints perfectly and does not exude from the joints in hot weather. Because it fills all joints perfectly and because of its rigidity, it is suspected that it will give added protection to the edges of the brick from wear by traffic. Its disadvantages are certain difficulties related to its removal from brick surface and its odor. Plasticized sulfur B also seems to bond well to brick and seems to flow well into all joints. It does not exude in hot weather.

One of the chief characteristics of plasticized sulfur that seems to recommend it for use in road construction is that it does not exude from joints in hot weather. Furthermore, it is sufficiently flexible to be deformed by any movements in the pavement itself, whether these movements are due to traffic vibrations or are caused by the expansion of the pavement itself owing to temperature fluctuations.

Membership in American Ceramic Society
FOR CONTINUING EDUCATION IN CERAMICS
Forward-going aggressive persons succeed only by continually studying, not narrowly, but broadly the current problems in all ceramic fields.

PRESIDENT'S MESSAGE

BIBLIOGRAPHIES

Herbert Spencer, somewhere in his autobiography, says of his early education (I may not be quoting his exact words): "If I had read as much as most people do, I should know as little as they."

A growing tendency to substitute reading for experience was one of the striking phenomena of the Nineteenth Century. The complete series of causes would be hard to trace, but the cheapening of wood-pulp by the chemist, the improvement of processes of typesetting and printing by the mechanical inventor, and Andrew Carnegie's philanthropies with their emphasis on books and learning, must all have played an important part. Early in the present century habits began to change, we began to substitute looking for experience, and instead of sitting for hours reading a book we sat for hours gazing at a screen. Today we substitute listening for experience and sit for hours in front of a loud-speaker.

Since the scientific and technical man still adheres to reading as his particular form of Sitzkraft, I am going to devote a few paragraphs to the subject of scientific and technical reading-matter, especially ceramic reading-matter.

In a presidential address before the Philosophical Society of Washington in 1921, I considered "The distribution of scientific information in the United States," and was astonished by some of my own data. One of the most impressive aspects of technical reading-matter was its bulk. At that time, for example, the American Chemical Society was distributing to each member, per year, 15 kilograms (33 lb.) of printed information, on 8400 pages. By experiment and calculation it was easy to show that to read aloud all this material (the only manner of reading that insures no lapse of attention) would require 64 full 8-hour days out of the available 365. This would have been only a beginning, for numerous other agencies were also publishing chemical information. On the other hand, its distribution by personal contact, by public lectures, by informational middlemen, and by museums and exhibitions, was found hopelessly inadequate. The printed page was then, and still is, the best means of distribution.

If one's purpose is to acquire knowledge of an unfamiliar subject in a short time, books are the most useful form of the printed page. Under the term "book" I would include any publication in which one subject or one group of related subjects is treated as a unit, with some attempt at completeness or comprehensiveness. Certain bulletins of federal and state technical bureaus would come under this classification, though by far the greater part of them are to be classed with periodical literature, which is in the nature of the case of limited scope and often only of temporary value.

The survey mentioned above brought out the somewhat surprising fact that books published for profit and sold at a good round price are more effective media for distributing information than books that are obtainable for the asking.

The book must be supplemented, however, by articles from the periodical literature, for few books succeed in coming nearer to up-to-dateness than two years, and most of them are from ten to twenty years behind. Unfortunately, periodical literature ramifies in a most complex and unpredictable way; hence its bibliography is a totally different thing from the bibliography of book literature.

No argument is needed to convince the experienced scientist or technologist that if he is going to accomplish anything in his chosen line of work, he cannot possibly read and digest everything that has been and is being written on his subject—unless he happens to be a pioneer in a new field, and even then he is well advised to make other people read his stuff, and to waste no time on theirs.

Recognizing the overwhelming and steadily growing bulk of scientific and technical reading-matter, we see that a complete and exhaustive bibliography of a subject, covering the particular as well as the general, is going to be useful to very few. It must be supplemented by some guide to the relative importance of the items, for the titles are often un-informing or even misleading, and nothing can be judged from the length, except that in a general way the better articles are shorter than the poorer. A grouping by subjects—and a grouping into reasonably small units—is another necessity. Two essentials in the compiling of a bibliography, therefore, are *selection* and *classification*. Both of these operations mean work; the preparation of a good bibliography is no mere mechanical task of index-making. It takes brains and a very extensive knowledge of a subject to prepare a useful bibliography of it.

Bibliographies themselves can be profitably classified on a time basis, and as an experienced user of printed information may I recommend the following to the attention of technical librarians:

A. A bibliography of 2 or 3 titles for the man who has to leave in thirty minutes to catch a train or plane to a distant conference, and must have some preliminary inkling of what it is all about.

B. A bibliography of 10 to 25 titles for the man who can afford to give from 3 to a maximum of 8 hours to the study of a subject, in anticipation of some operating decision, patent suit, or similar occasion.

C. A bibliography of 5 to 10 titles, all books, supplemented by the names and addresses of 3 to 5 of the principal periodicals, for the reader who wishes to inform himself at leisure.

D. A classified bibliography for the individual who is actively working at a problem and wishes to keep constantly in touch with many aspects of it. Such a bibliography is out of date before it can be printed, and is best

issued in card or mimeograph form and managed by an expert distributor of information.

These general considerations are as true of ceramic literature as they are of any other branch. We have a few good books that are useful to all ceramists. We have books on special branches of ceramics such as glass and refractories. We have an enormous range of books on the ceramic arts. And we have a very heterogeneous periodical and pamphlet literature running into thousands of titles and ramifying into all kinds of related sciences, such as chemistry, physics, and geology, with their many subdivisions. Our Society keeps efficiently abreast of this with its *Ceramic Abstracts*.

Concerning bibliographies in this field let me insist, again, that selection and assortment are the essentials. Accuracy is assumed as a matter of course. Completeness is of secondary importance,[1] except to the Patent Office.

Goethe's well-known dictum is even more applicable to technical bibliography than to most human activities: *In der Beschränkung zeigt sich der Meister.*

Or if you don't like these learned references in a foreign language, let me put it this way: If you must compile and publish bibliographies, for the love of Clio make'em snappy!

—ROBERT B. SOSMAN

[1] An exception is the bibliography of titles by a single author, such as the excellent one of H. LeChatelier in our October *Ceramic Abstracts*, pp. 316–22. Completeness is here of first importance.

REPORT OF MEETING OF BOARD OF TRUSTEES, AMERICAN CERAMIC SOCIETY, SEPTEMBER 12, 1937, HELD AT J. T. LITTLETON'S COTTAGE ON LAKE KEUKA

The members in attendance were: Sosman, Flint, McKinley, Kelsey, Carruthers, Child, and Littleton. Dr. Rolf Schultze of Deutsche Glastechnische Gesellschaft, Frankfurt, Germany, was also present though not attending the Board's session.

(1) Report of the Executive Committee Meeting of June 14, 1937, was read and approved.

(2) *1938 Annual Meeting.* It was decided that general sessions would be held Monday forenoon and the afternoons of Monday, Tuesday, and Wednesday.

Division meetings will be held the forenoons of Tuesday, Wednesday, and Thursday, and Thursday afternoon.

One general session should be devoted to structural ceramics including glass, reinforced masonry, etc.

The President's Reception and the Orton Lecture should be combined for one evening, possibly on Tuesday.

There shall be no organized entertainment at the hotel, but the local people should be asked to organize scheduled and guided tours of restaurants and other points of interest.

The Tulane University and the Newcomb College will be asked what entertainment and visits to laboratories and museums they will offer.

The question of finances for the Annual Meeting is to be referred to the Finance Committee, the personnel of which is Bales, Flint, and Carruthers, with power of final decision. The Board, on motion, unanimously agreed that the Local Committee shall not raise any funds whatsoever for entertainment. The Finance Committee will determine on the amount of the registration fees and the sum to be appropriated to finance the operating and entertainment expenses.

(3) *Institute of Ceramic Engineers.* The report by Carruthers dated September 7, was presented. On motion by McKinley, seconded by Carruthers, Item I was adopted.

On motion of McKinley, seconded by Flint, recommendation II was adopted with some editorial alterations, such as "that the Institute shall be initiated by certain members," rather than "formed by certain members" and that the word "Founders" shall precede the word "group" in the sentence in the "B" section.

On motion of Flint, seconded by McKinley, items III to VII were approved in principle, the thought being that the details should rest with the Founders' Group. This motion by Flint and McKinley included the recommendation that there be no dues, and that for the present the Institute be financed by appropriation from the Society's general funds.

On motion of Child, seconded by Kelsey, J. L. Carruthers was appointed temporary chairman of the Founders' Group.

It was moved by McKinley and seconded by Kelsey that the Institute of Ceramic Engineers should be incorporated under the laws of Ohio. Adopted.

(4) *Compensation Insurance.* The Board again unanimously decided that compensation insurance for the employees should be taken out, and that the Finance Committee should make the necessary investigations and secure the proper classification so as to obtain the lowest possible insurance rate.

(5) *New York Meeting Deficit.* It was moved by Flint and seconded by Child that the Secretary should make no further efforts to collect $500 from C. N. Nichols of the New York Convention and Visitors' Bureau. Adopted.

(6) *Allocation of Portion of Dues to Local Sections.* This was discussed but no action was taken.

(7) *Advertising Rates.* It was moved by Flint, seconded by Littleton, that the question of adjusting advertising rates be referred to the Finance Committee. Adopted.

(8) *Deposit of Money in Excess of $5000.* It was moved by McKinley, seconded by Child, and unanimously adopted that the money of the Society shall be deposited in Federal Reserve Banks and that not more than $5000 be deposited in any one bank.

(9) *Northern California Section.* It was moved by Carruthers, seconded by Kelsey, and unanimously adopted to grant a charter to the Northern California Section.

(10) *Structural Clay Products Research Institute.* This was discussed but no action taken, due to absence of a report from Secretary Stevens.

(11) *1939 Summer Meeting, San Francisco.* It was moved by Carruthers and seconded by Kelsey, and unanimously adopted that the Society should stage a meeting in the early part of July and not later than August 15 in San Francisco in 1939.

(12) *E.C.P.D. Report by Greaves-Walker.* It was moved by Carruthers and seconded by Flint that Mr. Greaves-Walker's report be accepted.

(13) *Encouragement to Enamelers' Clubs.* The Secretary

reported the extent and nature of his supporting activities in the organizing of enamelers' clubs. Without a formal vote the Board approved these promotional activities.

(14) *Publication of Book List.* By motion of Littleton, seconded by Flint, the printing of this list was held in abeyance subject to further consideration.

(15) *Appointment of Representative to 21st Anniversary of the Department of Glass Technology, Sheffield, England.* The communication of W. E. S. Turner, dated July 29, was read by Dr. Sosman. Dr. Turner asked that this Society appoint a delegate to attend the celebration of the 21st anniversary of the founding of the Department of Glass Technology. It was suggested that members of the Glass Division be circularized to ascertain what members will be in England on November 9 and 10, 1938.

(16) *Chairman of Patent Committee.* Dr. Sosman presented the situation developed by correspondence between J. C. Hostetter, F. H. Riddle, and Fulton B. Flick. Without formal motion it was the unanimous opinion that this Committee should be activated and placed under the chairmanship of Fulton B. Flick, % Brown, Critchlow & Flick, 1705 First National Bank Bldg., Pittsburgh, Pa.

Report of Organizing Committee of Institute of Ceramic Engineers

The Organizing Committee for the Institute of Ceramic Engineers of the American Ceramic Society has completed its survey of the membership of the Society to determine the answers to the questions set up by the Executive Committee of the Board, *viz.*,

I. How many members of the Society are interested in joining the proposed Institute?

II. What type of By-Laws with respect to membership are desirable?

The summary of the returns from the questionnaire is attached to this report, and the principal comments made by members are included. It is believed that the returns made on the questionnaire are quite high; there are others in the Society, however, who have postponed answering but who will undoubtedly want to join the Institute. Therefore, in view of the evidence submitted, your Committee makes the following recommendations:

I. That the organization of the Institute of Ceramic Engineers of the American Ceramic Society be started immediately.

II. That the following plan of organization be used which is thought to be best fitted because of the various questions that have been raised, and is contingent upon the recommendations concerning By-Laws.

a. That the Institute be initiated by certain members of the Society who will be known as the *Founders' Group* and all of whom will have full membership status.

b. A member of the Society who shall be eligible and invited to become a member of this Founders' group shall have the following qualifications:

1. He shall be a graduate of a recognized ceramic engineering school (Bachelor, Master, Doctor, or Professional degree).
2. He shall have been actively and continuously engaged in the practice of ceramic engineering for 10 years or more since the completion of his basic collegiate engineering work.
3. He shall be a member in good standing in the American Ceramic Society.

NOTE: The practice of ceramic engineering is defined in the report of the Education Committee of the American Ceramic Society presented in March, 1937. The promotion of ceramic engineers to executive positions in the ceramic industry and continued work therein shall be considered as active practice. (See *The Bulletin*, March 1937, p. 111.)

III. That the membership By-Laws of the Institute should make provision for the admission of the following qualified persons, all of whom must be engaged in ceramic engineering work:

a. Graduate ceramic engineers.

b. Other engineering or scientifically trained graduates.

c. Other persons who by experience and record can qualify.

IV. That the following years of experience in the industry should be required for admission as Associate Members of the Institute:

a. Ceramic engineers—3 years after graduation.

b. Other engineers—5 years after graduation.

c. Nontechnically trained engineers—7 years' experience in recognized work.

V. That the Founders' Group immediately organize the following Committees:

a. Rules.

b. Membership.

VI. That the preceding named Committees have the organization completed before the Annual Meeting of the Society in March, 1938, so as to start receiving applications for membership before that time.

VII. The membership qualifications must be kept at a high standard if this organization is to have merit and fulfil its responsibilities.

VIII. H. E. White, as a member of the Committee, suggests that provision should be made for admitting some engineers to the Founders' Group who do not have a ceramic engineering degree but he has not proposed a method for their selection.

—J. L. CARRUTHERS, *Chairman*
R. E. BIRCH
C. M. DODD
E. H. FRITZ
H. E. WHITE

Membership in The American Ceramic Society Means *Month-by-Month* Ceramic Progress

One and Thirty-Four Corporation and Personals in October The Good Ship Ceramic Crew Is Increasing More Are Needed

1937 MEMBERSHIP RECORD

Date of Record	Members Paid		Deferred	Subscrip-tions	Monthly Sales	Total Circulation
	Personal	Corporation				
December 20, 1937	1452	196				
January 20, 1937	1478	199				
February 23, 1937	1579	210	19	515	220	2543
March 29, 1937	1613	212	18	524	220	2587
April 23, 1937	1517	209	29	485	220	2460
May 22, 1937	1541	209	25	501	220	2496
June 22, 1937	1572	211	23	502	220	2528
July 20, 1937	1607	212	20	506	220	2565
August 23, 1937	1634	215	17	509	220	2595
September 23, 1937	1647	217	19	509	220	2612
October 23, 1937	1681	218	16	512	220	2647

Membership applications received prior to January 1 will, if the applicant so elects, be received as of 1938 and will receive the November and December, 1937, issues of the three monthly publications, (a) Journal, (b) Ceramic Abstracts, and (c) The Bulletin.

NEW MEMBERS

Corporation

PORTSMOUTH CLAY PRODUCTS Co., A. C. Judd (voter), Portsmouth, Ohio. (Formerly as personal membership for A. C. Judd)

Personal

BENOLIEL, D. J., Quaker Chemical Products Corp., Conshohocken, Pa.; general manager.

BLANKENSTEIN, EDWARD E., 2103 S. 51st St., Cicero, Ill.; ceramic engineer, Western Electric Co.

* CLAWSON, C. D., Caixa Postal 2948, São Paulo, Brazil.

GENTRY, RAYMOND, Kerr Glass Mfg. Corp., Sand Springs, Okla.; chemist.

GRAVELING, W. J., P. O. Box 559, Laredo, Texas; vice-president, Texas Mining & Smelting Co.

HOEPPNER, W. L., Latchford Glass Co., Florence Branch, Box 507, Los Angeles, Calif.; glass technologist.

KENWORTHY, ORVILLE O., B. F. Drakenfeld & Co., Inc., 45–47 Park Place, New York, N. Y.; technologist.

MILLSOM, WALTER C., 400 N. Y. Life Bldg., Kansas City, Mo.; research engineer, W. S. Dickey Clay Mfg. Co.

MODIGLIANI, PIERO, Livorno-Via delle Cateratte 25, Leghorn, Italy; managing director.

MULVANE, O. E., P. O. Box 117, West Lafayette, Ohio; ceramic engineer, Moore Enameling & Mfg. Co.

REMINGTON, VICTOR H., Box 519, Washington, Pa.; technologist, B. F. Drakenfeld & Co., Inc.

ZEILLER, IRWIN F., B. F. Drakenfeld & Co., Inc., 45–47 Park Place, New York, N. Y.; secretary.

Student

BELL, W. C., University of North Carolina.

CONNELLY, WILLARD S., Virginia Polytechnic Institute.

MARMONT, PAUL H., University of Washington.

MCCLEISH, LELAND J., University of Illinois.

SAWYER, JOHN P., JR., University of North Carolina.

SHORTER, A. J., Birmingham University, Birmingham, England.

VAUGHAN, T. CARTER, Virginia Polytechnic Institute.

Membership Workers' Record

Corporation

R. A. Heindl	1

* Indicates former member of the Society rejoining for 1937.

Personal

H. B. DuBois	1	R. B. Sosman	3
F. C. Flint	2	H. F. Staley	1
H. V. Kaeppel	1	Office	3
F. R. Porter	1		

Student

A. I. Andrews	1	A. F. Greaves-Walker	1
F. H. Clews	1	J. W. Whittemore	2
J. O. Everhart	1	Hewitt Wilson	1

Grand Total	20

ROSTER CHANGES DURING OCTOBER

Personal

CARMODY, ELMER J., 2 Rural Route, Ada, Mich. (Springfield, Ohio)

CLARK, EMORY W., Georgia School of Technology, Ceramic Dept., Atlanta, Ga. (Dry Branch, Ga.)

ECHAVARRIA, NORMAN, Steinthals Ltd., P. O. Box 237, Manchester, England. (New York, N. Y.)

FISK, HENRY G., Angels Camp, Calif. (San Andreas, Calif.)

GREEN, M. EDWARD, Iowa State College, Ames, Iowa (Taylorville, Ill.)

HURST, THOMAS L., 605 W. Ohio St., Urbana, Ill. (Leonia, N. J.)

JORDAN, SUZANNE, Franklin Square House, Boston, Mass. (Columbus, Ohio)

RUSSELL, RALSTON, JR., Ohio State Univ. Eng. Expt. Station, Columbus, Ohio. (Metuchen, N. J.)

THOMPSON, NOEL M., 452 Beaver St., Beaver, Pa. (Columbus, Ohio)

WINSHIP, WILLIAM W., 12 E. 46th St., New York, N. Y. (Brooklyn, N. Y.)

Student

BROOKS, SYDNEY J., Ohio State University. (Cleveland, Ohio)

CARSON, B. R., JR., Virginia Polytechnic Institute. (Wakefield, Va.)

DAMMANN, ARTHUR, University of North Carolina. (Amityville, N. Y.)

HAVELL, RICHARD F., University of Illinois. (River Forest, Ill.)

HENDREN, ROBERT R., Ohio State University. (Cleveland, Ohio)

SMITH, ALFRED, W., N. Y. State College of Ceramics. (Fonda, N. Y.)

CERAMIC SCHOOL NOTES

STUDENT BRANCH, VIRGINIA POLYTECHNIC INSTITUTE

The Virginia Polytechnic Institute Student Branch of the American Ceramic Society has been fully organized for the session 1937–1938. The group is functioning under the leadership of the following officers: *President*, A. M. Harvey; *Vice-President*, T. C. Vaughan; and *Secretary-Treasurer*, R. G. Charles.

There has been a decided increase in the number of students enrolled in Ceramic Engineering at V.P.I. this year. The enrollment has quadrupled itself in the last three years. There are now six seniors, six juniors, six sophomores, six freshmen, and one graduate student enrolled in Ceramic Engineering. Professors Whittemore and Dear are members of this Branch, and Professor Whittemore is councillor.

There have been two interesting meetings held this year. Talks were given by seniors, the first on "Tunnel Kilns, Their Design and Operation," and second, "Navy Department's Method of Testing Refractory Lining for Navy Boilers." Both of these talks were illustrated with slides.

This Branch of the Society meets on the first and third Thursdays of each month. The meeting is in charge of one of the junior or senior members who gives a talk on work in the ceramic field.

STUDENT BRANCH—GEORGIA SCHOOL OF TECHNOLOGY

The Georgia Student Branch is functioning actively. Officers elected in October were: H. B. Grace, *President*, Darroh Nowell, *Vice-President*, R. B. Williams, *Secretary* and *Bulletin Correspondent*, and M. J. Scavens, *Treasurer*. The older members welcomed the sophomores (eighteen in number) at a weiner roast and organization meeting on October 6.

AMERICAN SOCIETY FOR TESTING MATERIALS

The next annual meeting of the A. S. T. M. will be held in Atlantic City, N. J., June 27 to July 1 (inclusive), 1938. The Spring Regional Meeting and Group Committee Meetings will be held in Rochester, N. Y., during the week of March 7.

FROM OTTAWA TO NEW ORLEANS

I am favorably considering being present at the New Orleans Meeting next March. There is so much of value to be received in attending Annual Meetings of the Society that one should not be adversely influenced by a somewhat longer than usual train journey. I expect that there will be at least two members of my staff present next March; if not, it will be because of pressure of work at the time.

The action of the Board of Trustees in extending the time for general sessions is I believe, a good move.

—HOWELLS FRÉCHETTE, *Chief*
Industrial Minerals Division
Bureau of Mines

FROM GEORGETOWN, ONTARIO, TO NEW ORLEANS

It is a truism that "all work and no play, makes Jack a dull boy." I favor the New Orleans meeting frankly as a well-earned winter holiday. All who attended the Atlanta and Macon Meeting, especially the ladies, remember it as one of our most enjoyable.

Also it has been my observation that these meetings, which arouse more of the holiday spirit, pay extra dividends in personal acquaintanceships which are often of as much value both to the individual and his firm as all of our compiled ceramic data.

I especially urge our Canadian members and all my friends of the Canadian Ceramic Society to plan to pack their bags about March 25 and go "a-visiting" down to old Louisiana. There will be shrimp and crab and lobster, grits and gravy, Spanish and Creole dishes, pralines and French drip coffee. I'll be seeing you.

—EARLE T. MONTGOMERY

SIXTH NATIONAL CERAMIC EXHIBITION

The first prize for ceramic sculpture was awarded to Miss Mathilde Parmelee of Edgehill School, Greenwich, Conn. This prize was $100 given by the Harshaw Chemical Company of Cleveland. The second prize of $100 was divided between Mrs. Ruth H. Randall of Syracuse University, Syracuse, N. Y., and Frederic Jean Thalinger of Antioch College, Yellow Springs, Ohio. This prize was offered by the Hanovia Chemical Company of Newark, N. J. The first honorable mention in sculpture was given to Sorcha Boru of Menlo Park, Calif. Other honorable mentions went to Adolph Odörfer of Fresno, Calif., and to Wilhelmine Rehm of Cincinnati, Ohio. Special mention in sculpture was given to Russell Barnett Aitken for his two glazed terra cotta figures. Miss Parmelee and Mrs. Randall are the first women to win prizes for sculpture.

Pottery prizes were awarded as follows: First prize of $100, given by the Onondaga Pottery Company of Syracuse to Roger D. Corsaw of the University of Oklahoma, Norman, Okla.; second and third prizes of $25.00 each, given by the B. F. Drakenfeld Company of New York, were awarded to Richard V. Smith of Syracuse and to Aloys Sacksteder of Sandusky, Ohio. First honorable mention was given to Glen Lukens of the University of Southern California, Los Angeles. Other honorable mentions for pottery were given to Edgar F. Littlefield, Ohio State University, Columbus, Ohio, William Soini, Brooklyn, N. Y., Arthur E. Baggs, Ohio State University, Columbus, Jean Cochran, Columbus, and to Harold E. Riegger, Alfred, N. Y.

A special purchase prize, given by the Ferro Enamel Corporation, was awarded to H. Edward Winter of Cleveland for work in enamel on metal.

The awards were made on the basis of creative design and sound craftsmanship. The judges for this exhibition were William M. Milliken, director of the Cleveland Museum of Fine Arts; R. Guy Cowan of the Onondaga Pottery, Syracuse; and Charles M. Harder of the New York State College of Ceramics, Alfred, N. Y.

More than 119 artists were represented in the Exhibition. To Miss Anna W. Olmsted, director of the Syracuse Museum of Fine Arts, belongs high honor and praise for her work in organizing the National Ceramic Exhibitions as a memorial to the late Adelaide Alsop Robineau of Syracuse.

Schedule for Circuit of Exhibition

(1) The Sixth Annual Ceramic Exhibition will remain at the Syracuse Museum of Fine Arts, James and North State Streets, from October 28 to November 22.

(2) Newark, N. J., Museum, December 1–December 27.

(3) George Walter Vincent Smith Gallery, Springfield, Mass., January 5–26, 1938.

(4) Cincinnati Art Museum, February 4–25, 1938.

(5) Newcomb College Art Gallery, New Orleans, La., March 15–April 6, 1938.

(6) Brooks Memorial Gallery, Memphis, Tenn., April 12–May 3, 1938.

The exhibition in New Orleans is scheduled to coincide with the Annual Meeting dates of the American Ceramic Society.

NECROLOGY

EDWARD E. KRAUSS

The death of Mr. Krauss occurred on May 13, 1937.

Mr. Krauss was born in Topeka, Kans., on Sept. 22, 1883. He received his preliminary education in Germany where his father was in the diplomatic service. On his return to this country he entered the University of Pennsylvania, and was graduated in 1907 as a mechanical engineer.

Edward Krauss

Mr. Krauss had been with the Chambers Brothers Company for fifteen years.

JOSEF VOLLKOMMER

Josef Vollkommer, a leading figure in the ceramic industry and president of the Vitro Manufacturing Company in Pittsburgh, died on October 24, 1937, in Bamberg, Bavaria, Germany.

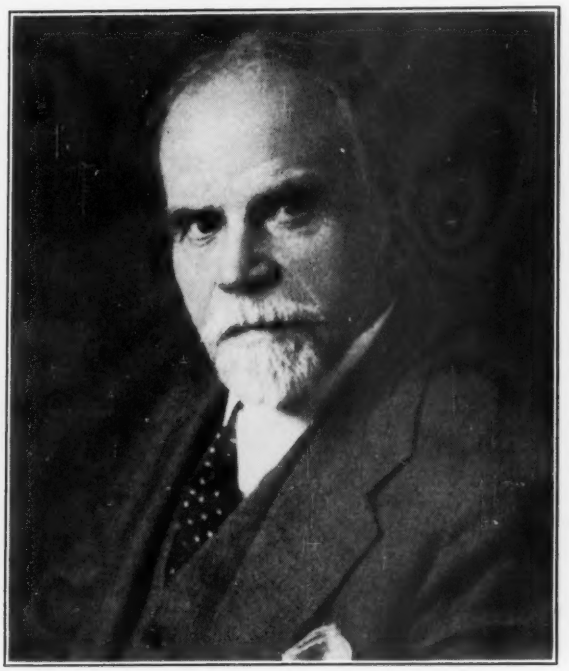
Only a few months ago, active and full of constructive plans for the future, he went on a brief visit to Europe and died suddenly in the town of his boyhood and youth—picturesque, ancient Bamberg, which he left in quest of a colorful career more than half a century ago.

At the age of 20, just out of the college in Hamburg, he decided to leave his native land and seek a new and unexplored field where he could apply his abundant energies and enterprise.

A military career appealed to his nature and he went to Holland to join the Royal Cadets, who were trained for service in the East Indies. A call from America, where his brother Theodore worked for Thomas A. Edison, prompted a different decision. The young cadet sailed for the United States in 1882.

At the beginning of the 20th Century, porcelain enameling was still in its infancy and Josef Vollkommer was one of its pioneers, with a vision of the unlimited possibilities of this growing, young industry.

In 1905 he formed a business partnership with his brother Theodore, Vollkommer and Company, for the purpose of manufacturing porcelain enamels, which were then mostly imported from Europe. A small manufacturing plant was set up in a suburb of Pittsburgh. It began to grow from the beginning, but a disastrous fire in 1908 destroyed everything but his faith in the bright future of porcelain enameling. With their capital gone, the brothers turned to consulting engineering. A little later, however, in a new, small shop, porcelain enamels were again made, and from this emerged the Vitro Manufacturing Company, incorporated under the laws of Pennsylvania in 1909. From the first day of Vitro's organization, he was its active president and leading spirit. Due to his untiring efforts and resourcefulness, Vitro expanded and grew to be one of the leading producers and purveyors of colors and chemicals to the ceramic industry.



Josef Vollkommer

His keen understanding of the needs of the industry and his helpfulness and loyalty to friends made Josef Vollkommer an outstanding personality and a directing figure in his chosen field.

Throughout his life he was an avid reader and student of history. He traveled in many countries and gave freely of his vast storage of knowledge and experience to the enameling industry in the United States, South America, Canada, and Mexico.

Josef Vollkommer will long be preserved in the memories of all who knew him.

ACTIVITIES OF THE SOCIETY

COX GIVES GOOD REASONS FOR ATTENDING THE MEETING IN NEW ORLEANS

Eight years of enjoyable residence in New Orleans taught me to know that those who fail to attend the coming Meeting of the American Ceramic Society will cheat themselves out of one of the most enjoyable holidays it is possible to have. Such a holiday, combined with the very important work always done at our Meetings, is a decided bargain.

New Orleans is a Latin city. Therefore it combines the love of pleasure with the love of culture, and is not above enjoying pleasures of a very unserious character, nor is it too frivolous to be serious about intellectual matters.

Grace King wrote a book, entitled New Orleans, The Place and the People, and curiosity about each word in that book title should be the key to enjoyment of the portion of the Meeting which falls outside of regular Meeting working hours.

There are no citizens more willing to be hospitable to strangers than those of New Orleans. There is no American city with as great a variety of interesting places to visit as New Orleans. It is probable that the weather will be obliging. It has always been so for Mardi Gras.

I urge every member of the American Ceramic Society to believe me when I state that one has only to ask and, without hope or expectation of profit, any person of any walk in life of the New Orleans citizenry will turn to you to make your visit full of great pleasure. New Orleans people like each other and like good people who enjoy doing worth-while things. There is no other city where it makes so little difference as to what is in a man's purse. The American Ceramic Society members will be liked more for what they have in their heads than for what they represent in bank accounts, and it is my sincere hope that all the members of our Society find out those things, and many others, for themselves.

I know these things to be true, because I have enjoyed nearly all of the pleasures enjoyed by the residents of New Orleans. My position while living in that city was a humble one and I did not have very much money at any time with which to repay kindnesses. These people do such things because they like to be courteous to strangers. It is this rich courtesy which will be missed by those who fail to go down to our great Old World city.

—PAUL E. COX

PITTSBURGH SECTION

On Tuesday, October 12, 1937, at 8:30 P.M., the Pittsburgh Section held a meeting at the Mellon Institute, 4400 Fifth Avenue, Pittsburgh, Pa.

N. W. Taylor of Pennsylvania State College spoke on "Some Technical Problems in the Beneficiation of Clays."

—W. C. RUECKEL, *Secretary*

WHITE WARES DIVISION NOMINATIONS

Officers nominated for the White Wares Division for the year 1938–1939 are:

Chairman: F. P. Hall, Pass & Seymour, Inc., Syracuse, N. Y.

Secretary: Karl Schwartzwalder, AC Spark Plug Company, Flint, Mich.

Trustee: E. H. Fritz, Westinghouse Electric & Mfg. Co., Derry, Pa.

Nominations: J. W. Hepplewhite, Edwin M. Knowles China Company, Newell, W. Va., and Ralph Hanna, National Tile Company, Anderson, Ind.

—R. F. GELLER, *Chairman*

OUR MISTAKE AND APOLOGY*

In today's number (September, 1937) of your *Bulletin* the picture shown does *not* represent my deceased husband,

Wilhelm Pukall

but instead the former Director of the Royal Porcelain Works of Berlin, Counselor Dr. Heinicke.

I am enclosing a picture of my deceased husband.

—FRAU PUKALL

* Editor's Note: The Obituary of Wilhelm Pukall was published in *Bull. Amer. Ceram. Soc.*, **16** [9] 376 (1937).

Valuable Bibliographies, a complete Ceramic Book List, and a Supplement to the Equilibrium Diagrams are in preparation, in addition to the regular monthly publications.

ENGINEERING CURRICULA ACCREDITED BY ENGINEERS' COUNCIL

For the first time in the history of engineering education in the United States, engineering curricula throughout the country have been appraised by a representative body of engineers, and a single accredited list has been published of courses of study deemed worthy of approval. The accrediting process has been carried out during the past two years by the Engineers' Council for Professional Development, a joint organization created by seven national engineering societies for the purpose of enhancing the status of the engineering profession. The participating groups are American Society of Civil Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Mining and Metallurgical Engineers, American Institute of Chemical Engineers, The Society for the Promotion of Engineering Education, and National Council of State Boards of Engineering Examiners.

Working through four committees, the Council inaugurated a program dealing with the selection, guidance, training, and recognition of members of the engineering profession. The objective of the Committee on Engineering Schools was "to formulate criteria for colleges of engineering, which will insure to their graduates a sound educational background for practicing the engineering profession," and to give recognition to those institutions prepared to teach engineering according to acceptable standards. Accrediting was based both on qualitative and quantitative criteria, and the procedure involved the use of an extensive questionnaire and a personal visit to each institution by a committee of engineers. Participation of the educational institutions was voluntary, and inspection was made only at their invitation.

Committee on Engineering Schools

The membership of the E.C.P.D. Committee on Engineering Schools is as follows:

K. T. Compton, Massachusetts Institute of Technology, *Chairman*, representing the American Institute of Electrical Engineers; H. P. Hammond, Pennsylvania State College, *Vice-Chairman*, representing the Society for the Promotion of Engineering Education; G. M. Butler, University of Arizona, representing the American Institute of Mining and Metallurgical Engineers; I. C. Crawford, University of Kansas, representing the American Society of Civil Engineers; H. A. Curtis, Tennessee Valley Authority, representing the American Institute of Chemical Engineers; P. H. Daggett, Rutgers University, representing the National Council of State Boards of Engineering Examiners; A. A. Potter, Purdue University, representing the American Society of Mechanical Engineers.

Basis for Accrediting Engineering Colleges

The following statement, proposed by the Committee on Engineering Schools and approved by the Council and by the constituent member organizations, embodies the principles in accordance with which accrediting is conducted.

I. Purpose of accrediting shall be to identify those institutions which offer professional curricula in engineering worthy of recognition as such.

II. Accrediting shall apply only to those curricula which lead to degrees.

III. Both undergraduate and graduate curricula shall be accredited. (Accrediting program at present embraces undergraduate curricula only.)

IV. Curricula in each institution shall be accredited individually. For this purpose, the E.C.P.D. will recognize the six major curricula: chemical, civil, electrical, mechanical, metallurgical, and mining engineering—represented in its own organization, and such other curricula as are warranted by the educational and industrial conditions pertaining to them.

V. Curricula shall be accredited on the basis of qualitative and quantitative criteria.

VI. Qualitative criteria shall be evaluated through visits of inspection by a committee or committees of qualified individuals representing the E.C.P.D.

VII. Quantitative criteria shall be evaluated through data secured from catalogues and other publications, and from questionnaires.

VIII. Qualitative criteria shall include the following:
- (1) Qualifications, experience, intellectual interests, attainments, and professional productivity of members of the faculty.
- (2) Standards and quality of instruction:
  - (*a*) In the engineering departments.
  - (*b*) In the scientific and other coöperating departments in which engineering students receive instruction.
- (3) Scholastic work of students.
- (4) Records of graduates both in graduate study and in practice.
- (5) Attitude and policy of administration toward its engineering division and toward teaching, research, and scholarly production.

IX. Quantitative criteria shall include the following:
- (1) Auspices, control and organization of the institution and of the engineering division.
- (2) Curricula offered and degrees conferred.
- (3) Age of the institution and of the individual curricula.
- (4) Basis of and requirements for admission of students.
- (5) Number of students enrolled:
  - (*a*) In the engineering college or division as a whole.
  - (*b*) In the individual curricula.
- (6) Graduation requirements.
- (7) Teaching staff and teaching loads.
- (8) Physical facilities. The educational plant devoted to engineering education.
- (9) Finances: investments, expenditures, sources of income.

Scope of Accredited List

This list includes only such undergraduate engineering curricula as have been judged by E.C.P.D. to be worthy of accrediting. It does not include certain specialized curricula submitted for consideration, which, though ap-

parently outstanding in restricted fields, are not closely related to engineering as it is interpreted by E.C.P.D.

In some cases accrediting has been made provisional for a limited period (from one to three years), with reappraisal stipulated at the end of the period. The provisional nature of the accrediting is based upon conditions which E.C.P.D. has found not to be entirely satisfactory, but which may be quickly improved, or conditions which are now satisfactory but whose future appears precarious. Such conditions include the following: uncertainty as to financial status; need for minor additions to staff or equipment; curricula, new or in state of transition; uncertainty due to nature of administrative organization; unusual dependence upon strength of a single individual. In every case where provisional accrediting has been granted, the institution has indicated that an effort will be made to remedy the unsatisfactory condition within the stipulated period of provisional accrediting. The fact that accrediting may thus be provisional is, in each case, a confidential matter with E.C.P.D.

E.C.P.D. has yet under consideration curricula at five institutions, which applied for accrediting with the request that the visits of inspection be made in 1937–1938.

The present list, dating from October 1, 1937, will again be subject to revision in the fall of 1938. It replaces the first partial list which was released for publication in October of 1936.

Ceramic Engineering Schools Accredited

University of Illinois (Technical Option), Missouri School of Mines and Metallurgy, New York State College of Ceramics (at Alfred University), North Carolina State College, Ohio State University, University of Washington.

Requests for further information regarding E.C.P.D. and the accrediting program may be addressed to A. B. Parsons, Secretary, Engineers' Council for Professional Development, 29 West 39th Street, New York, N. Y.

RELATION OF THE AMERICAN CERAMIC SOCIETY AND THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

By R. A. Miller

From the associations which it has been my privilege to enjoy both in the American Ceramic Society and the American Society of Heating and Ventilating Engineers, it seems to me very evident that both societies have considerable community of interest. Recently this thought has been emphasized by the creation within the organization of the A.S.H. & V.E. of a "Technical Advisory Committee" to assist the Research Committee in its study of "air-conditioning requirements of glass."

The newer developments in the field of glass-heat insulation, glass blocks, "glass wool," multiple glazing, and the increasing intensities of illumination, all lead to closer coöperation between the two societies. The Joint Committee on Illuminating Glassware, formed by our Society, the I.E.S., and the Glassware Guild, should extend, or the parent societies should extend, an invitation to the A.S.H. & V.E. to participate in its deliberations.

In connection with air-conditioning developments which are rapidly becoming more widespread throughout the country, the use of glass for structural as well as the other more usual applications is becoming increasingly apparent and important. The effective insulation of the air-conditioning ducts against heat and sound offer many interesting possibilities from the point of view of the glass producer. The high relative humidities advocated by the air-conditioning engineer necessitate adequate insulation of walls and windows to prevent excessive condensation and enable the maintenance of the desired relative humidities. In ordinary building construction, as most of us know it today, a relative humidity materially in excess of 20% is almost entirely precluded if we wish to maintain our homes, office buildings, and factories as livable places. The use of glass block, double-glazed windows, and the application of glass wool and similar materials to the insulation of walls permits much higher humidities without condensation and should make it possible to maintain humidities as high as 45 to 50%. This seems to be the accepted figure which the A.S.H. & V.E. normally advocate.

The work which our Society has undertaken relative to the mechanical strength and general physical properties of glass is of extreme interest to the heating and ventilating engineer in considering the cost of installation of his equipment where glass materials can be used. This, of course, includes the application of glass materials to certain refrigeration problems with which both the A.S.H. & V.E. and the American Society of Refrigerating Engineers are concerned.

During the past few years, at its research laboratory in the Bureau of Mines building in Pittsburgh, the A.S.H. & V.E. has conducted some interesting and extensive experiments to determine the sun effect upon walls and roofs of buildings and the consequent amount of refrigeration in terms of tons of ice which would be required to air-condition buildings properly with various exposures. These investigations have included studies on the effects of heat-absorbing, configurated, and obscure types of glasses in various types of installations. They involve determinations of the heat transfer through glass, both by direct radiation and conductance, in terms of B.t.u. per hour per square foot per degree F difference between the inside and outside temperatures. These experiments have been conducted under ordinary atmospheric conditions and have given some interesting results. They have included the use of various types of heat screen, such as awnings, Venetian blinds, both internal and external, ordinary window curtains, etc.

Several glass companies have conducted extensive experiments along similar lines, and the Pittsburgh Plate Glass Company has had a large amount of work done by the Pittsburgh Testing Laboratories and in its own laboratory organization covering certain phases of heat transfer

through multiple glazing at temperatures extending from several degrees below zero up to usual atmospheric summer-time conditions.

Reference has been made to the Technical Advisory Committee of the A.S.H. & V.E. and it is interesting to note the number of glass men included in the Committee membership: F. L. Bishop, University of Pittsburgh; U. E. Bowes, Owens-Illinois Glass Company; A. N. Finn, National Bureau of Standards; E. H. Hobbie, Mississippi Glass Co.,; George B. Watkins, Libbey-Owens-Ford Glass Co.; W. W. Shaver, Corning Glass Works; J. T. Staples, Macbeth-Evans Div. of Corning Glass Works; R. A. Miller, Pittsburgh Plate Glass Co.; E. J. Lillibridge, National Door Manufacturers' Assn.; F. W. Parkinson, N.S.W. Co. of Detroit; W. C. Randall, Detroit Steel Products Co.; Cyril Tasker, Ontario Research Foundation; F. C. Weinert, Chamberlain Metal Weatherstrip Co., Detroit; M. L. Carr, Pittsburgh Testing Laboratories, *Chairman;* and *Ex-Officio,* W. A. Danielson, Chairman of the A.S.H. & V.E. Research Committee and F. C. Houghten, director of its research laboratory.

At the St. Louis meeting of the A.S.H. & V.E., the Technical Advisory Committee adopted the following resolution: "Be it recommended that the American Society of Heating and Ventilating Engineers Research Laboratory add to its research staff a man whose duties shall be as follows: (1) to make a thorough investigation into the existing information and data pertaining to the work of this Technical Advisory Committee; (2) to correlate data and information on the various phases of the work of the Technical Advisory Committee; (3) to supervise any specific research or tests to which he may be assigned; that the cost of maintaining said man be financed by all companies or associations interested in the studies of this Technical Advisory Committee and that any specific research projects to be carried on under this Technical Advisory Committee be financed by the particular branch of the industry interested; and be it further recommended that the first specific research undertaken be a study of the heat transfer, including solar radiation, through glass building units and flat glass windows."

Ways and means for financing the employment of this man were discussed, and it was agreed that the different branches of the industry should each be made responsible for a part of the budget. These subdivisions include (1) manufacturers of glass building units and flat glass for glazing, (2) metal window sash and frame manufacturers, (3) wood window manufacturers, (4) weather-strip manufacturers and caulking-compound manufacturers, and (5) sun-arresting appurtenance manufacturers.

It is anticipated that the first year's experience under this plan will demonstrate its utility, and it is proposed to continue the project only so long as results seem to be obtained. Progress reports will be made to each donor from time to time, and at the end of any year unexpended funds will be returned to the donors pro rata or will be applied to subsequent contributions, at the option of the donor.

After considerable discussion of this question, the following glass companies have been asked to participate in the program: Blue Ridge Glass Co., Southwestern Glass Co., Sergeant Glass Co., Franklin Glass Corp., Mississippi Glass Co., Pennsylvania Wire Glass Co., Pressed Prism Plate Glass Co., American Window Glass Co., Fourco Glass Co., Corning-Macbeth Glass Co., Owens-Illinois Glass Co., Libbey-Owens-Ford Glass Co., and Pittsburgh Plate Glass Company.

TECHNICAL SALES ENGINEER,
PITTSBURGH PLATE GLASS COMPANY
PITTSBURGH, PENNSYLVANIA

FERRO ESTABLISHES FOUR NEW FELLOWSHIPS

As early as 1924, the Ferro Enamel Corporation of Cleveland, Ohio, recognized the need for experiment and research in their comparatively new industry and established the Cushman Fellowship at Western Reserve University in Cleveland.

This year the Cushman Fellowship has been granted to Nelson Perry Nies, A.B. and M.A. in Chemistry, California Institute of Technology. Working under the direction of H. S. Booth, Mr. Nies will continue the study of the fundamental reactions involved in porcelain enamel frits.

At Case, R. R. Schauss will devote all of his time to "Study of Factors Relating to Suitable Cast Iron for Leadless Enameling." This fellowship is under the direction of A. C. Coffinberry and H. A. Schwartz. The latter, besides being a lecturer at Case, is also manager of research for the National Malleable & Steel Castings Co.

At the University of Illinois, under the direction of A. I. Andrews, Thomas L. Hurst, A.B., University of North Carolina, M.S., University of Washington, has been assigned the problem, "Physical and Chemical Study of Soluble Salts Present in Mill Liquors, Including Their Relation to Total Solubility and Selective Crystallization on Drying."

W. B. Felter, B.S., in ceramic engineering, New York State College of Ceramics, has been awarded the Fellowship at Ohio State University for research work on "Sagging: Causes of and Methods of Elimination." Mr. Felter will work under the direction of R. M. King.

The fourth Fellowship established this year is at New York State College of Ceramics, Alfred, N. Y. This was granted to Wilfred Paquin for "Studies of Domestic Clays and Clay Blends; Methods of Improving Clays for Porcelain Enamel." C. R. Amberg is the director of this Fellowship.

Besides the five just mentioned, Ferro is also a contributor to the Fellowship which is being carried on under the direction of the Porcelain Enamel Institute. G. T. Rankin, Ph.D., Ohio State University, holds the Fellowship on this project.

Along with this wide-spread work being done in universities all over the country, Ferro also carries on an extensive research program in its own laboratories. G. H. McIntyre, Ferro's Director of Research, states that a large share of all the laboratory time is devoted to problems other than those involved in current manufacturing operations.

EDWARD ORTON, JR., CERAMIC FOUNDATION ANNOUNCES SCHOLARSHIP AWARDS FOR 1937–1938 COLLEGE YEAR

The Edward Orton, Jr., Ceramic Foundation was created by the will of the late Edward Orton, Jr., and through a trusteeship is operated for the benefit of the ceramic industries. In addition to the manufacture of standard pyrometric cones for the measuring and controlling of kiln firing operations, the Foundation is entrusted with the promotion of ceramic knowledge and to this end has established a group of fellowships for advanced ceramic research at American universities. These fellowships, which are awarded for two-year periods, are located in universities providing instruction in ceramics and are under the direction of the ceramic departments. The number of fellowships awarded each year is regulated by the income from the sale of standard pyrometric cones.

Two fellowships were awarded in 1934, three in 1935, three in 1936, and four in 1937. The research subject is chosen by the university where the grant is made and approved by the Foundation. Publication of results is a responsibility of the university concerned.

For the 1937–1938 college year the following fellowships are announced: University of Illinois, subject, "Some Factors Controlling the Uses of Clay," Felix Fraulini, Fellow; Ohio State University, subject, "An Evaluation of the Methods for Testing Glaze Frit," W. C. Bell, Fellow; Pennsylvania State College, subject, "The Mechanism of Phase Changes in Silica," C. Y. Lin, Fellow; Rutgers University, subject, "A Study of the Protective Colloid Mechanism in Clay Suspension," A. W. Helz, Fellow.

In addition to the above researches, the Foundation is continuing at its own laboratories several investigations aimed to improve the standard pyrometric cones as to accuracy of softening under variable furnace conditions, and also in regard to uniformity of shape and structure. These improvements in cones have involved considerable expense for new equipment and, as the obligations of the Foundation as received from the Orton estate are disposed of, an increased number of fellowships are planned. The Foundation hopes that through the opportunities of these Fellowships a constantly increasing number of men will be trained to attack ceramic problems in a systematic manner, thus supplying more able technologists to this field.

MISSISSIPPI CLAY INVESTIGATIONS

By W. C. Morse,* G. H. Woollett,† and V. A. Coulter‡

As early as 1929, the Building Commission and the Board of Trustees of the University of Mississippi made provision for the Mississippi State Geological Survey and the Department of Geology jointly to begin the testing of the clays and other mineral resources of the State. At that time the Head of the Department of Geology and the Director of the Survey, E. N. Lowe, was directed to purchase clay and other mineral testing machinery and furniture to equip rooms that were to be added to the old building to house them. Accordingly, he purchased somewhere between $6000 and $10,000's worth of such equipment and furniture. Unfortunately, the funds were exhausted before these laboratories were erected, and the machinery and most of the furniture have remained in storage until 1937.

During the early part of this year, the Department of Chemistry of the University very generously came forward with an offer to provide two or more basement rooms in the Chemistry Building, making it possible for the Survey and the Department of Geology to enter into agreement with the Department of Chemistry whereby at least some of this furniture and equipment could be set up in the basement rooms for the joint use of the Survey and the Geology and Chemistry departments. This has already been done and the part-time services of Roy Mills, a potter who has had experience in commercial establishments and who has had training in the Chicago Art Institute, has been secured. In fact, Mr. Mills has made, from samples of Mississippi clays, sufficient ware for two or three kilns, which have already been fired.

The Survey has been fortunate to secure the half-time services of Louis C. Conant, a Dartmouth man, who did his graduate work for the Ph.D. degree at Cornell University under Heinrich Ries, one of the foremost clay geologists of the United States. After spending nine weeks in the Summer School at the University of Mississippi, Dr. Conant began his duties as Associate Professor and Assistant Geologist in September. Nearly half of his time will be devoted to the study of Mississippi clays.

The Survey has also been so fortunate as to secure the services of Frederic F. Mellen, a young geologist of great promise, who is a former student of the present Director and who is now finishing his work at the University of Mississippi for the Master's degree, the thesis for which has already been published by the Mississippi Geological Survey as *Bulletin*, No. 34, "The Little Bear Residuum." The Survey admits with considerable chagrin that it has been compelled to take advantage of Mr. Mellen's temporary release as assistant geologic aid to the TVA to secure his services at a salary that can not even be justified on the grounds of inadequate appropriation. Mr. Mellen will have charge of the clay investigations of Winston County for the WPA. Samples collected in this work will be tested in the kilns of the Survey at the University. As soon as this project is completed clay investigations of other counties will be undertaken.

In fact, the Director of the Survey, William C. Morse, who was granted an honorary fellowship in ceramic art at Ohio State University for the second summer term, plans a complete investigation of the clays of the whole State just as rapidly as funds are provided for that purpose—the investigation to be according to the latest

* Director, Mississippi Geological Survey, University, Miss.
† Professor of Chemistry, Univ. of Miss.
‡ Dean, College of Liberal Arts, Univ. of Miss.

approved standards and to include the current problems of the ceramic industries that are already established. Bentonitic clays, kaolinitic clays, bauxitic clays, ball clays, and other clays are too valuable assets of the State to suffer further delays in testing. In coöperation with the Chemistry Department, which will make use of the equipment in its courses in industrial chemistry, the Department of Geology will offer some introductory courses in ceramic art.

The Chemistry Department expects to include use of the ceramic equipment in the laboratory work in industrial chemistry and hopes also to carry on some research work in clay treatment. With this in view, Glenn W. Parsons has been added to the chemistry staff as assistant professor.

Dr. Parsons has held the Cushman Fellowship of the Ferro Enamel Corporation at Western Reserve University for the past three years and has recently received his doctorate in chemistry from that institution. While pursuing graduate work, he spent some time in the plants of the Ferro Enamel Corporation.

Not only will routine tests and investigations be made, but above all, the Mississippi Geological Survey hopes, with this joint personnel, to begin the study of a series of research problems that will lead to economical methods of beneficiation of Mississippi's clays and other minerals and to discover new uses for these natural resources.

Victor A. Coulter

Academic Record

B.S. 1913, M.S. 1914, Ph.D. 1916, University of North Carolina.

Victor A. Coulter

Teaching Experience

Instructor in Chemistry, University of North Carolina, 1916–1917; Assistant Professor in Chemistry, 1920–1925; Associate Professor in Chemistry, 1925–1926; Professor of Physical Chemistry, University of Mississippi, 1926–; Dean, College Liberal Arts, 1935–.

Other Experience

Summer, Research Chemist, Armstrong Cork Company, 1917; Lieut. and Capt., C.W.S., 1917–1919; Capt. C.W.S., O.R.C., 1925–.

Societies

Member of American Chemical Society, Phi Beta Kappa, Reserve Officers Assn., National Rifle Assn.

Glenn W. Parsons

Academic Record

Undergraduate student, Parsons College, Fairfield, Iowa, 1928–1929, 1930–1933, B.S. magna cum laude, 1933; graduate student and research fellow in chemistry and ceramics, 1934–1937, Western Reserve Univ., Ph.D. 1937.

Glenn W. Parsons

Teaching Experience

Laboratory assistant in Chemistry, Parsons College, 1931–1933; instructor in Chemistry, Parsons College, 1933–1934; Assistant Professor of Chemistry, Univ. of Miss., 1937.

Industrial Experience

Research at Ferro Enamel Corporation, Cleveland, Ohio.

Societies

Phi Kappa Phi, Sigma Xi, American Chemical Society.

Frederic F. Mellen

Academic Record

Graduate Starkville, Miss., High School in 1928; B.S. Mississippi State College, 1934; graduate study Mississippi State College and University of Miss.

Employment

Tennessee Valley Authority—Civil Works Administration Dec., 1933–April, 1934, work on mineral resources of northeastern Mississippi; Tennessee Valley Authority, June–September, 1934, working on investigation of mineral resources and dam sites in northeastern Mississippi; graduate assistant and curator of Geology Museum, Mississippi State College, 1934–1935; Tennessee Valley Authority May, 1935–June, 1937, work on mineral resources and dam site investigations in northeastern Mississippi, northern Alabama, and central Tennessee; commencing August 1, 1937, as Assistant Geologist, Mississippi Geological Survey.

Frederic F. Mellen

Publications

The Bentonite Deposits of Mississippi, *Rocks and Minerals*, November, 1936.

The Little Bear Residuum, *Miss. Geol. Surv. Bull.*, No. 34, 1937.

New Forms of the Genus *Lituola* from Mississippi (with Alta Ray Gault), in preparation.

Member of Paleontological Society.

Guy H. Woollett

Academic Record

B.S. 1910, M.S. 1916, Ph.D. 1918, University of Minnesota.

Teaching Experience

1916–1918, Assistant Professor of Chemistry (Organic and Physiological), Univ. of Miss.; 1918–1920, instructor in Chemistry (Organic), Univ. of Minn.; the following posts were held at the Univ. of Miss.: 1920–1926, Associate Professor of Chemistry (Organic and Physiological); 1926–1930, Professor of Physiological Chemistry; 1930–1932, Head, Dept. of Chemistry; 1932–1937, Professor of Organic and Physiological Chemistry; 1937—Head, Dept. of Chemistry.

Louis C. Conant

Societies

Member of American Chemical Society; Fellow, A. A. A. S.; Sigma Xi; Mississippi Academy of Sciences.

Louis C. Conant

Education

B.A. Dartmouth College, 1926 (majored in sociology); M.A. Cornell University, 1929 (thesis: Contributions to the Geology of the Ossipee Mountains of New Hampshire. Unpublished); Ph.D. Cornell, 1934 (thesis: Geology of the New Hampshire Garnet Deposits).

Teaching Experience

Instructor in Geology, Dartmouth, 1926–1927; assistant in Geology, Cornell, 1927–1928; instructor in Geology, Cornell, 1928–1929, 1930–1937; instructor Cornell Summer Session, 1931, 1932, 1933, 1935; short course in seismology for graduate students, 1935–1937; Associate Professor of Geology, Univ. of Miss., 1937–; Assistant Geologist, Miss. Geol. Surv., 1937–.

Field and Other Experience

Univ. of Chicago camp in Ozarks, 1927 (faulted sedimentary rocks); parts of summers 1927, 1928 in Ossipee Mountains, N. H. (igneous rocks); field geologist and prospector for ore deposits, No. Rhodesia, 1929–1930 (igneous, sedimentary, metamorphic rocks); parts of summers 1931–1933 N. H. garnet deposits (igneous and metamorphic rocks); summer 1934, in Sierra Nevada using Cloos method on igneous and metamorphic rocks, with E. B. Mayo; part of summer 1936 studying structural disturbances around a granite intrusion, near Thetford, Quebec; operated Cornell seismograph, 1934–1937; and several years teaching and graduate work among the slightly disturbed Paleozoic sediments of N. Y. State.

Travel

Rhodesian copper mines, South African gold, platinum, diamond mines, and Dwyka glaciation; various metallic and nonmetallic deposits of N. Y. and New England; Appalachian and Piedmont region of North Carolina and Virginia; and Grand Canyon and Yosemite National Parks, and Gaspé Peninsula.

Publications

Optically Positive Cordierite from New Hamsphire, *Amer. Mineralogist*, Vol. 20, pp. 310–11 (1935).

The New Hampshire Garnet Deposits, *Econ. Geol.*, Vol. 30, pp. 387–99 (1935).

A New and Cheaper Photo-Cell Circuit for Recording Time on Seismograms (abstract of paper read at meetings of eastern section, Seis. Soc. Am., Ottawa) Earthquake Notes, Vol. 7, p. 14 (1935).

Protruding Crestlines of Waterfalls (abstract) *Proc. Geol. Soc. Amer.*, p. 71 (1935).

Southern extension of the Mono Craters, California (joint paper) *Amer. Jour. Sci.*, Vol. 32, pp. 81–97 (1936); Other papers and investigations in progress.

Member of Sigma Xi.

William C. Morse

Academic Record

Undergraduate student, Ohio State Univ., 1902–1906, B.A. 1906; graduate student (and instructor), Ohio State University, 1906–1910; M.A. 1908; graduate student, Univ. of Chicago, 1911 (summer), 1913–1914; graduate student, Mass. In t. of Technology, 1926–1927; Ph.D. 1927; Honorary Fellow, Ohio State Univ., summer 1937.

Teaching Experience

Fellow in Zoölogy, Ohio State Univ., 1906–1907; fellow and assistant in Geology, Ohio State Univ., 1907–1908; instructor in Geology, Ohio State Univ., 1908–1913; university scholar in Geology, Univ. of Chicago, summer 1911; instructor in Geology, Washington Univ., St. Louis, 1914–1916; Assistant Professor in Geology, Washington Univ., 1916–1918; Professor and Head of the Department of Geology, Miss. State College, 1918–1934; Visiting Professor of Geology, Univ. of N. Carolina, 1930–1931; Professor and Head of the Dept. of Geology, Univ. of Miss. (and Director, Miss. Geological Survey), 1934–.

Field Work

Geological Survey of Ohio, Geological Survey of Kentucky, Ohio Academy of Science, summers, 1907–1910; State Highway Department of Ohio, geologist, field seasons 1912–1913; Illinois Geological Survey, oil and gas, July to December, 1914; summer, 1915; oil survey, geological structure in Kansas, summer, 1916; oil survey, geological structure in Kansas, Illinois, and Missouri, summer, 1917; consulting geologist to various companies, Ohio, Ill., Mo., Okla., Texas, Louisiana, and Mississippi, 1914—; Kentucky Geological Survey and Mississippi Geological Survey, summers, 1919–1921; Appalachian field trips, summers, 1922, 1923; Pacific field trip, 1924; Ala., Tenn., Ky., and Ohio, summer field trip, 1925; Mississippi Geological Survey, summer, 1926; Tenn., Ky., Ohio, and New York, summer, 1927; Canada, Ohio, and N. Carolina, summers, 1928–1931; Adirondacks, Vermont marbles, Quebec asbestos, 1932; central and northern Ohio, 1933; Norris Dam, New York State Parks, Virginia, Federal, Ohio, Ind., and Ill. Geological Surveys, 1934; New York State flood, 1935; Great Smoky National Park, French Broad-Pigeon Physiography, 1936; Roosevelt State Park, Legion State Park, 1937.

Publications of W. C. Morse

The Columbus Esker, *Ohio Naturalist*, **7**, 63–72, 1907.

Contribution to the Life History of Cornus Florida, *Ohio Naturalist*, VIII, 197–204, 1907.

The Waverly Formations of East Central Kentucky (with August F. Foerste), *Jour. Geol.*, **17**, 164–77 (1909).

The Richmond-Lorraine Line (with Aug. F. Foerste), Geol. Surv. of Ohio, Geological Map of Ohio, by J. A. Bownocker, 1909.

Outlines of Field Trips in Geology for Central Ohio (with C. S. Prosser), 74 pp., 1910.

The Maxville Limestone, Geol. Surv. of Ohio, *Bull.*, **13**, 128 pp., 1910.

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Building Stones of Ohio (Review), *Stone*, XXXVII, 245–47, 1916.

The Origin of the Coarse Breccia in the St. Louis Limestone (bstract), *Science*, XLIII, 399–400, 1916.

Combination of Structures in the Colmar Oil Field in Western Illinois (abstract), *Science*, XLIII, 400, 1916.

A Power Chisel for Paleontologic Laboratories, *Science*, XLIV, 142–43, 1916.

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A Geological Field Trip, *Science*, LIX, 523–24, 1924.

Field Trips in Geology, *Science*, LXIII, 617, 1926.

Paleozoic Rocks of Mississippi, *Jour. Geol.*, **36**, 31–43 (1928).

Memorial—Paul Franklin Morse (with San Antonio Geological Society), *Bull. Amer. Assn. Petroleum Geologists*, **13**, pp. 1501–1503, (1929).

Paleozoic Rocks, Miss. Geol. Surv., *Bull.*, No. 23, 212 pp., (1930).

The Topography of Lion's Head Shore Line, Canada, *Owen Sound Daily Sun-Times*, page 9, September 6, 1930.

A Natural Bridge, Georgian Bay, *Can. Geographical Jour.*, **2**, 247–52, (1931).

Pennsylvania Invertebrate Fauna, Kentucky State Geol. Surv., Vol. 36, 293–349, 1931.

Ephraim Noble Lowe, *Bull. Amer. Assn. Petroleum Geologists*, **18**, 428–430, (1934).

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Geologic Conditions Governing Sites of Bridges and Other Structures, Miss. Geol. Surv., *Bull.*, No. 27, 1935.

Frances Hartwell Walthall, *Oxford Eagle*, April 4, 1935.

The Geologic History of the Vicksburg National Military Park Area, Mississippi Geol. Survey, *Bull.*, No. 28, 1935.

Fifteenth Biennial Report, Miss. Geol. Surv., 1934–1935.

The Tupelo Tornado, Mississippi Geol. Survey, *Bull.*, No. 31, 1936.

Reason and Revelation (review), *The Chronicle*, Vol. XXXVI, No. 9, June, 1936.

Tishomingo State Park—Geologic History, Miss. Geol. Surv., *Bull.*, No. 32, 1936.

Textbook on Geology, Part I, 509 mimeographed pp.

Tombigbee State Park—Geologic History, Miss. Geol. Surv., *Bull.*, No. 33, 1936.

The Geologic History of Legion State Park, Miss. Geol. Surv., *Bull.*, No. 35, 1937.

Societies

Sigma Xi, Ohio Academy of Science, Fellow; American Association for the Advancement of Science, Fellow; Paleontological Society; Geological Society of America, Fellow; Mississippi Academy of Science.

OWENS-ILLINOIS GLASS COMPANY DEDICATES RESEARCH LABORATORY

Wednesday, October 20, the Owens-Illinois Glass Company was host to about two hundred at the dedication of its new research laboratories. It was a fitting tribute to Games Slayter, Director of Industrial and Structural Products Laboratory. The plant, laboratory, and all operations were inspected and explained in complete detail. Indeed, it was an open house reception and dedication that withheld no production secrets; an experience unusual, yet increasingly the vogue.

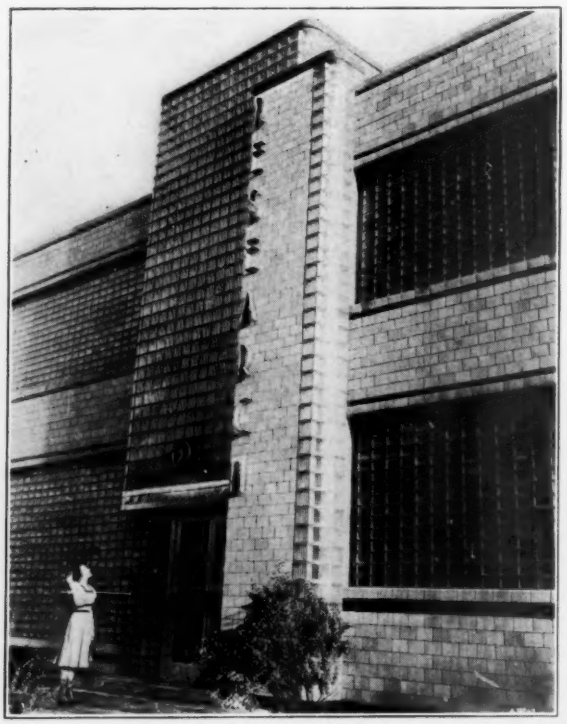

FIG. 1.—Alice in Wonderland (1937 model), hearing that a milk bottle, in the hands of modern Aladdins, can be turned into threads of pure glass for weaving into cloth, decides upon a personal investigation and, as pictured here, visits the new research laboratory of the Owens-Illinois Glass Company's Fiberglas division in Newark, Ohio. There she met the men who discovered the process by which insulation and textile glass is now produced in America and Europe.

Glass Technician Reveals How "Accident" Brought Europe Hurrying to Doorstep of Newark, Ohio, Laboratory

The method to produce Fiberglas today in this country and abroad is the result, primarily, of a discovery made by glass technicians while they were seeking a process to improve the attractiveness of a milk bottle as a package.

This interesting fact was revealed recently in Newark, Ohio, when plans were being formulated for dedicating the new Fiberglas Research Laboratory of the Owens-Illinois Glass Company.

"Our Fiberglas process was discovered in 1932," explained one of the research men, "when we were trying to find a method to fuse color to the sides of milk bottles so that dairy firms, for instance, could have their names and slogans, or even cartoon and other characters, imprinted permanently in any desired color upon the container as a merchandizing aid.

"We tried different methods. One of them involved the use of a blow-torch, *i.e.*, melting finely powdered colored glass and forcing it simultaneously under pressure against the milk bottle. The glass did not adhere as we desired, but it was noted the glass was being 'blown' into tiny filaments that piled up in a fluffy mass alongside the bottle.

"We had not been thinking in terms of fibrous glass but realized, naturally, that we had 'bumped into something,' as it were. An examination revealed that the fluffy mass of glass weighed only about one pound per cubic foot.

"It had been known that a crude form of insulation glass was being produced in Europe, but the thing that aroused our interest was the fact that European insulation glass weighed six pounds per cubic foot, whereas our accidentally discovered fibrous glass weighed about one pound per cubic foot. Weight is, of course, a highly important factor in insulation.

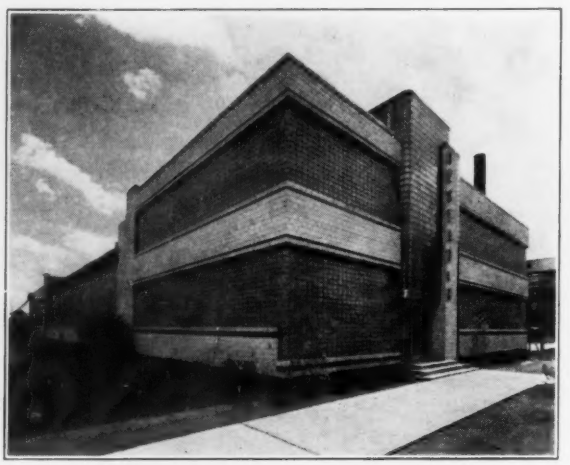

FIG. 2.—A "glass house" for glass men. Housed in an ultra-modern laboratory having walls of glass block, a product of their fellow workers in Muncie, Indiana, technicians of the Owens-Illinois Glass Company at Newark, Ohio, do research and experimental work in connection with Fiberglas—pure glass in textile forms of thread and yarn for application in many fields new to glass. (C. Wilbur Foster, Indianapolis, Architect.)

"We invented machinery to produce fibrous glass for insulation, made such glass commercially practical early in 1934, and then began experiments with Fiberglas for textile purposes."

Glass in fiber form has an interesting history. There is

no authentic account, but it may well be assumed that glass itself, discovered long before the birth of Christ, was closely followed by discovery of its fiber form. Drawing a spear head out of the first puddle of glass, our distant ancestor probably noticed the glass fiber, noted, too, that as he drew the spear faster, the thread was finer.

For centuries, however, no one suspected the wonderful properties of fiber glass. The Venetians of the Middle Ages, who guarded the art of glassmaking so closely, made a few articles of "spun" glass by heating glass rods and drawing them out into thread form. In 1908, a professor at the University of Prague discovered that fibers in matted form made a good heat insulator, but primitive production methods—the same as employed by the Venetians—limited quantities and improvements and high cost prohibited its use.

With the coming of the World War, Germany's Canadian asbestos supply was cut off. A substitute was imperative—something to mix with infusorial earth for mechanical strength to withstand vibration in railways and ships; a strong, nonburnable fiber at any cost. Necessity being the well-known "mother of invention," the Germans turned to glass fiber and improved the crude methods then in use.

As early as 1921, all German locomotives were insulated with glass "wool" blankets. German battleships had been using the material. After the war, other European countries sought and obtained licenses to produce such glass under rights from German inventors.

Recently, research experts of the Owens-Illinois Glass Company have returned from European countries where they supervised installations of machines made in Newark, Ohio, to produce insulation and textile glass by the Owens-Illinois method.

Licenses have been granted to Actien-Gesellschaft der Garresheimer Glashüttenwerke, Düsseldorf, Germany; Cie de St. Gobain, Paris, France; and to Chance Brothers & Company, Ltd., of Glasgow, Scotland.

FIBERGLAS PRODUCED BY TWO PROCESSES

Precious Metal Bushings Used to Form Molten Glass Into Tiny Filaments by Drawn and Blowing Methods at Newark, Ohio

Fiberglas today is made by two methods developed by the Owens-Illinois Glass Company at Newark, Ohio. One is known as the "continuous filament" process, and the other is referred to as the "staple fiber" method.

The manner of melting glass is identical in both processes. Glass marbles are fed into electrically heated furnaces. Each furnace, regardless of process, has a trough or V-shaped bushing made of costly metals of a higher melting point than glass.

Molten glass, entering the open or wide top end of the bushing, is "drawn" downward by gravity in the continuous process method, the glass emerging from 102 tiny holes in the bottom of the bushing.

The filaments, almost too small to be seen with the naked eye, unless light strikes the shiny fibers properly, combine to make one strand considerably smaller in diameter than human hair.

To be exact, the filaments average 0.00025 inch in diameter, and can be made with a diameter of only 0.00005 of an inch. Human hair has an average diameter of 0.0010 of an inch, cotton fiber averages 0.0004 and silk fiber diameters average between 0.00002 and 0.00004 inch.

The 102 filaments of glass fiber are combined to make one thread-like strand measuring 0.024 inch in diameter for winding upon spools. The spools are transferred to machines for fabrication into insulation tapes and cloths.

In the staple process, the molten marbles are forced downward through tiny holes of the same type of costly metal bushing, but instead of being "drawn," as in the continuous process, they are blown downward by steam under high pressure.

Passing through a burst of glass flame to eliminate moisture, the fibers gather upon and are drawn from a revolving drum. White as snow, the accumulation or "silver" follows grooved wheels to be wound on swiftly revolving spools. These are taken to ordinary textile spinning machines for twisting and reduction to thread for fabrication.

CRANDON WITH HARTFORD-EMPIRE

The latest addition to the Hartford-Empire Company organization is Albert S. Crandon, who started his new position early in October.

Mr. Crandon was born in New Bedford, Mass., and was graduated from the Worcester Polytechnic Institute.

Albert S. Crandon

For two years following his graduation he was retained at Worcester Tech. as instructor. Later he was in the employ of the American Bridge Company at Ambridge, Pa.

During the war Mr. Crandon served in the 304th Regiment of Engineers, which he entered as Second Lieutenant. After seeing active service in France, he was made Captain of Engineers in 1918, and became acting head of the Intelligence Section after the Armistice. Upon his return to the United States he resumed his work with the American Bridge Company.

Mr. Crandon has had extensive experience in the glass business, having been with the American Window Glass Company since 1923. He will be employed at the Hartford-Empire Company under J. C. Hostetter, head of the Development and Research Department, where he will devote special attention to furnaces and related problems in glassmelting. He will be associated directly with Vergil Mulholland, who is well known as one of the leaders in this branch of the glass business.

The technical and engineering force of the Hartford-Empire Company has been greatly increased in the last few years and the Company is now in position to give complete service to its licensees.

HIGH-TEMPERATURE ELECTRIC FURNACE ELEMENT EXHIBITED UNDER OPERATING CONDITIONS

An electric furnace element capable of operating at 3000°F is being exhibited under operating conditions in Pittsburgh. The element has been developed by Paul Schwarzkopf, a famous pioneer in powder metallurgy, in his laboratories at Reutte, Austria. The makers claim that such elements, after operating 4400 hours at a temperature of 3000°F, have shown no evidence of deterioration. As a result of tests made in Europe, the element appears to be resistant to hydrogen, oxygen, hydrocarbon, sulfur, and its combinations. The element holds out much promise of being used in air, neutral, reducing, and oxidizing atmospheres, in vacuum, or even in sulfurous atmospheres. It should, therefore, be suitable for use in glass furnaces and ceramic furnaces, as well as in the metal industry.

Arrangements for the testing were completed in behalf of Mr. Schwarzkopf by P. T. Wetter, American Cutting Alloys, New York City. Mr. Wetter stated that manufacturers and users of electric furnaces would be invited to check the tests and that M. H. Mawhinney, consulting furnace engineer of Salem, Ohio, has been retained to work with furnace manufacturers in studying the new element to see its application in industrial furnaces. If the element fulfills the claims made for it, the manufacture in this country will be started.

W. J. WESTPHALEN ELECTED PRESIDENT AMERICAN REFRACTORIES INSTITUTE

At the Colorado Springs meeting of the American Refractories Institute, Frank Piatt resigned from the presidency of the Institute, effective October 1, 1937.

At the same meeting, W. J. Westphalen was elected to fill the vacancy made by Mr. Piatt's leaving, and will serve in the capacity of president for the unexpired term. Mr. Westphalen is vice-president of the Laclede-Christy Clay Products Co. of St. Louis.

CHEMICAL INDUSTRY MEDAL

The Chemical Industry Medal of the Society of Chemical Industry was presented to E. J. Crane, editor of *Chemical Abstracts*, at a joint meeting of the American Section of the Society of Chemical Industry and the American Chemical Society on Nov. 5, 1937, with James G. Vail presiding. The medal is awarded annually for valuable application of chemical research to industry and was given this year to Mr. Crane for his work in abstracting technical and scientific writings in all fields of the chemical industry.

Mr. Crane presented a paper entitled "Words and Sentences in Science and Industry," and Austin M. Patterson of Antioch College spoke on the life and accomplishments of the medalist. A. E. Marshall made the presentation of the medal.

The meeting was held at 8:00 P.M. at the Chemists' Club, 52 E. 41st St., New York City. A dinner in honor of Mr. Crane was given at the club preceding the meeting.

SASKATCHEWAN STUDENT BRANCH CANADIAN CERAMIC SOCIETY

The first meeting of the new year of the Student Branch of the Canadian Ceramic Society was held on Tuesday, Oct. 12, at the University of Saskatchewan. At this meeting, along with a discussion of plans of the year's activities, an election of officers was held. The results of the election were as follows: *Councillor*, W. G. Worcester; *President*, J. L. Ellis; *Vice-President*, J. Simpson; *Secretary-Treasurer*, V. C. Howie, and *Librarian*, H. Priest.

One or two of our senior students will probably join the American Ceramic Society this year.

—V. C. Howie, *Secretary-Treasurer*

FORD MOTOR COMPANY OFFERS 16MM FILM SOUND EQUIPMENT

The new sound picture "The Ford Rouge Plant" has just been released for showing. Reservations for showing it may be made through your nearest Ford Dealer. There is no charge for the use either of the equipment or operator.

The Ford Motor Company also offers the following films: (1) "Glacier International Park," (2) "Yellowstone National Park," (3) "Adventure Bound."

RADIO INTERFERENCE-PROOF INSULATORS

Westinghouse radio interference-proof high-voltage pin-type insulators are the subject of a new leaflet issued recently. The leaflet describes the method of applying copper oxide glaze, the application of insulators, and methods of testing for radio interference.

DONALD W. ROSS WITH LACLEDE-CHRISTY

Donald W. Ross has been appointed a member of the Research Division of the Laclede-Christy Clay Products Company, specializing in glass industry refractories.

Plan to Attend Annual Meeting
New Orleans, La.
March 27–April 2, 1938

TO NEW ORLEANS FOR THE FORTIETH ANNUAL MEETING WEEK OF MARCH 27, 1938

ANOTHER FAVORABLE TESTIMONY

I had very much the same experience that you are having now when I solicited aggressively the attendance in New Orleans of The American Association of Museums, whose membership is widely scattered throughout the nation. My first two invitations were not accepted because of the distance and because our city was not considered a museum center. As a matter of fact, New Orleans is a museum in itself. It is the abode of the muses. The fact that it is not a center of ceramics is a very good reason why those interested in this art and industry should come.

After the meeting of the American Association of Museums, there was a new interest in New Orleans and our work, and the museum world benefited by it. So in the case of your members—their presence here will attract our large population and those who read our newspapers to this presently not-much-discussed or revealed subject matter. I stated to the American Association of Museums that it was almost their solemn duty to assist me in focusing the attention of the people of New Orleans and Louisiana and the South upon the value of museums, and so I believe that your members might view their trip from this angle and develop an apostolic zeal for the creation of a new impetus for their work in a section which knows little about it. I say "little about it" with reservation, for we are extremely proud of the work of the Newcomb Art School and of the creative imagination exhibited by the Woodwards and by that unsurpassed ceramic expert *par excellence*, Joseph Meyers.

Your visit may cause the Louisiana State University to open a department for the teaching of the youth of our land. Tulane University may be stimulated to action. We at the Museum might receive additional gifts and loans of works of art. New Orleans is glamorous, it is a lovely place in which to be, and to reach it one must traverse the very heart of the United States. May your members kindle a sacred fire of propaganda amongst us of their great mission in life.

—James A. Fortier, *President, Louisiana State Museum*

CONFIDENTIAL LETTER REGARDING ANNUAL MEETING IN NEW ORLEANS

"I locked horns with the handsome old Colonel—what the dickens is his name?—who came here last spring to look over the possibilities. He had his underlip sticking out and was most skeptical about the Meeting's success in such a hole as New Orleans which had absolutely nothing to offer a visitor of brains looking toward ceramic possibilities.

"I retorted that men of brains sometimes were interested in seeing how the other half of this great land lived, and that quite often men of brains—and women—fixed up with an apparatus for comparing life and ways of getting through it—got quite as much out of travel by enlarging their experience as by seeing mills and cut-throat enterprises. I pointed out the easy possibility of having their learned essays read by highbrow visitors who could come loaded with all the modern dope, thus bringing light and learning to those of us who sit in darkness. I don't believe he was impressed, but I fancy he is a good poker player."

DON HAGAR BOOSTS NEW ORLEANS MEETING

"To answer your letter of October 20—my only reason for considering the Annual Meeting in New Orleans is because I attend these Meetings wherever possible for their educational value and the business contacts that can be made. The fact that the Meeting is to be held in New Orleans, where the climate is pleasant and much of historical interest is to be seen, greatly increases the anticipation of the Meeting itself." —Don Hagar

A MESSAGE FROM DICK

From the conversations I have had with a great many of the members, I feel sure that the attractiveness of the city of New Orleans is going to bring a large attendance and, too, I feel that the atmosphere and surroundings at the New Orleans Meeting will assist that feeling of cheer and good fellowship that always improves the discussions and interchange of ceramic knowledge both in and out of the Meetings.

I am looking forward to seeing you in New Orleans.

—Dick Carothers

GREYHOUND BUS FARES TO NEW ORLEANS

	One Way	Round Trip
Houston, Tex.	$6.50	$11.70
Dallas, Tex.	7.75	13.95
Ft. Worth, Tex.	8.30	14.95
San Antonio, Tex.	9.50	17.10
El Paso, Tex.	19.45	35.05
Los Angeles, Calif.	27.50	49.50
San Francisco, Calif.	27.50	49.50
Seattle, Wash.	36.00	64.80
Denver, Colo.	20.25	36.45
Kansas City, Mo.	13.20	23.85
St. Louis, Mo.	9.50	17.10
Chicago, Ill.	12.30	22.15
Memphis, Tenn.	6.50	11.70
Cincinnati, Ohio	10.75	19.35
Detroit, Mich.	14.20	25.60
Chattanooga, Tenn.	6.75	12.15
Pittsburgh, Pa.	14.50	26.10
Atlanta, Ga.	6.65	12.00
Washington, D. C.	13.85	24.95
New York, N. Y.	16.55	29.80
Savannah, Ga.	8.80	15.85
Jacksonville, Fla.	8.20	14.80
Tampa, Fla.	10.65	19.20
Miami, Fla.	12.95	23.35

MODERN NEW ORLEANS

New Orleans often is pictured as an old world mystery because of the atmosphere of old France and old Spain to be found in its Vieux Carré, or original city. Many persons also like to think of it as the city that hides behind a laughing mask because of Mardi Gras, the Sugar Bowl Classic, the Spring Fiesta, outdoor sports throughout each month of the year, and glamorous night life.

New Orleans has preserved its historic landmarks and has kept alive the stories of the romance and tragedies identified with them with just the same reverence which has prompted its people to bury the dead in costly marble tombs. New Orleans loves to play, to mix business with pleasure without detriment to either because play, Orleanians contend, helps them to work better.

No wonder, then, that that city has become the greatest city in the South with a population in excess of 500,000; has become the fourth largest city in the United States in area; a southern industrial center of the first magnitude; a leading wholesale and retail center of the South, its great financial center; and the gateway to the world for the products of the world's richest valley, the Valley of the Mississippi.

From the economic viewpoint, New Orleans occupies an advantageous position in its location on the Mississippi River 107 miles from the Gulf of Mexico. The river at New Orleans is wide enough and deep enough to float the greatest of ships and that means that the ports of the world are within easy reach. Thirteen thousand miles of inland waterways terminate at New Orleans and make it the country's grand central station for the river steamboat and the barge line. Rail lines, motor truck lines, and air lines complete the transportation picture to give mysterious, laughing New Orleans distribution facilities unmatched anywhere else.

Because the interception of foreign raw materials at the port of entry offers a distinct economic advantage; because in the area around the city there is a natural storehouse of resources, like oil, sulfur, and salt; and because a moderate climate makes possible uniform year-round operation in manufacturing plants, beneath the mysteries of New Orleans and behind that laughing mask members of the American Ceramic Society will find a thriving industrial city with more than one thousand plants producing considerable wealth in the form of sugar, bags, petroleum, coffee, cigars, rice, and a myriad of other products. New Orleans makes 80% of the men's wash suits worn in this country, is the home of the cotton-seed products industry, is one of the leaders in the production of industrial alcohol, a southern center for the manufacture of modern and period furniture and produces all of the wallboard that comes from sugar-cane bagasse.

New Orleans was the wealthiest city in the country during the good old days of the steamboat. The influence of that amazing era is still felt and embodied in the magnificence of its modern homes and buildings and other achievements. Canal Street, for example, has sidewalks and neutral grounds paved with marble and is America's widest business thoroughfare.

The influence of that golden era was also at work even during the late depression when New Orleans built monuments to progress in the form of the Shushan airport, the Mississippi River's greatest bridge, and unique Bonnet Carré Spillway which is helping to tame the sometimes turbulent old Father of Waters.

Shushan Airport on Lake Pontchartrain has no peer, aviation authorities say. Six million cubic yards of material was pumped from the lake bottom to make land for the field and buildings. The Airport, only five miles from the business district, forms a part of the 40-million dollar new New Orleans "front yard" which was made from the reclamation of two thousand acres of land. An outstanding residential and resort district and waterfront playground is now going up along the new shores of the lake that Bienville named two centuries ago in honor of the minister of marine of France.

During December of 1935, a New Orleans dream of decades became a reality when the 13-million dollar toll-free Huey P. Long Bridge across the Mississippi River was dedicated—an engineering achievement believed impossible. The central pier, from the bottom of its foundation 170 feet below mean Gulf level to the top of the superstructure, is 409 feet high, equal to a 36-story building. Traffic now moves west unimpeded.

Although the Mississippi River has not overtopped the levees at New Orleans in more than 100 years, the Bonnet Carré Spillway, a product of the United States Army Engineers, now stands thirty-three miles above the city to give further security to New Orleans from river floods by removing the crests in the river to Lake Pontchartrain before they reach the city. The Spillway, extending for 7700 feet along the river, was put into operation for the first time in February, 1937, and proved its efficiency by lowering the water level at New Orleans several feet. It can take care of more water than flows over Niagara Falls.

And yet even more ambitious plans have been laid by New Orleans for the future, to be told in such accomplishments as the repaving of the streets, the construction of a new $12,000,000 Charity Hospital, a $2,200,000 Federal Building, a new City Hall, French Market, and other improvements.

Yacht Club

SOME ECONOMIC ASPECTS OF NEW ORLEANS

With a population now estimated at more than 500,000, New Orleans is foremost among the cities of the South. It is the fourth largest city in the United States in area, a southern industrial center of the first magnitude, a leading wholesale and retail market of the South, its greatest financial center, and the gateway for the Mississippi Valley to the world.

Location

Located on the Mississippi River, 107 miles from the Gulf of Mexico, New Orleans is within convenient reach of the ports of the world. The city is the center of a large area of population, wealth, and business activity, divided fairly evenly between the states east and west of the Mississippi River. The area comprises the states of North and South Carolina, Georgia, Florida, Tennessee, Alabama, Louisiana, Oklahoma, and Texas with a population of 28,735,200.

The distance from the Panama Canal is 600 nautical miles less than from New York to Panama. New Orleans is nearer than Atlantic ports by 400 to 1000 miles to the ports of Central America, Mexico, Cuba, Chile, Colombia, Ecuador, Peru, Venezuela, China, Japan, Australia, and the Philippines.

The Port

More than 3000 ships clear from the port of New Orleans each year. Port and river improvements, valued at 200 million dollars, have been constructed to handle the 8 million tons of freight that move over the wharves in a normal year. The port comprises the harbor frontage of Orleans Parish and parts of Jefferson, St. Bernard, and Plaquemine parishes, totaling forty-one miles on the Mississippi River and eleven miles on the Inner Harbor Navigation Canal.

Port facilities have 7.71 miles of wharves, including 5.50 miles of steel and concrete transit sheds, the world's largest shipside cotton warehouse, with a capacity of 400,000 high density bales, a public grain elevator with capacity of 2,600,000 bushels, coal and bulk commodity handling plant, vegetable oil handling plant, banana conveyers and terminals with capacity for handling 2500 bunches an hour, and other public and private terminal and warehouse facilities.

The principal exports are petroleum and products, lumber and millwork, grain and flour, cotton and other textiles, iron and steel products, paper and manufacturers, lard and compounds, tobacco, carbon black, molasses and syrup, rosin, salt, and sulfur and chemicals.

The principal imports are sugar and molasses, petroleum and products, bananas, bauxite, coffee, sodium nitrate, creosote oil, jute and manufactures, vegetable oils, logs, sisal, paper and manufactures, and chemicals.

Raw Materials

Oil, salt, sulfur, natural gas, limestone, cane products, rice, cotton, timber and other resources make the area around New Orleans a veritable natural storehouse of chemical and other raw materials, unmatched anywhere else in the United States. Nearby, too, is the greatest fur-producing area in the western hemisphere, as well as the largest shell fisheries operations. Many raw materials from foreign countries reach this country through the port.

Industry

In the New Orleans industrial zone, 1100 concerns manufacture more than 1000 different articles, including sugar, burlap and cotton bags, alcohol, celotex, petroleum refining, cotton-seed products, meat products, coffee, syrups and molasses, textiles, cigars and cigarettes, flavoring extracts and cordials, rice cleaning and polishing, fertilizer, clothing, binder twine, and furniture.

New Orleans makes 80% of the men's wash suits worn in the United States, is the home of the cotton-seed products industry, is one of the leaders in the production of industrial alcohol, a southern center for the manufacture of modern and period furniture, and produces all of the wallboard that comes from the sugar-cane bagasse.

Transportation

Nowhere else in this country may be found such a complete coördination of transportation facilities as offered by New Orleans: trunkline railroads, inland waterways, coastwise steamship service, overseas steamship service, and air service. Railroad trunk lines entering New Orleans offer direct service to the large centers of the South. Barge lines operate from New Orleans to Minneapolis, St. Paul, St. Louis, Kansas City, Chicago, and to points in Alabama and in Texas. Coastwise steamship service is offered to the Atlantic, Pacific, and to ports on the Gulf. The foreign steamship service is offered to and from New Orleans to all parts of the world and is more complete, extensive, and regular than from any other American port except New York. Mail, passenger, and express air service is offered to the north, east, and west, with overnight schedules to all parts of the country.

Inland waterways, totalling 13,000 miles, connect New Orleans by way of the Mississippi River system with the major producing centers of the world's richest valley, that of the Mississippi. The Intracoastal canal gives New Orleans direct water access to points westward in Louisiana and Texas and is being developed eastward as far as Florida and northward along the east coast of Florida and Atlantic states.

The Public Belt Railroad, owned by New Orleans, with ninety-five miles of tracks, brings the various terminals facilities, and carriers of the port into a compact, efficient unit.

Facts

Bank deposits in New Orleans in 1936 amounted to $253,059,001, greatest in the South. Automobile registrations totaled 79,000. Sewerage and water and drainage facilities are valued at $61,425,000. A total of 257 miles of street car and bus routes serve the city. More than 74,000 telephones are in use.

Oil Developments

New Orleans is seen as the future oil capital of the country by J. A. Shaw, chief of the Minerals Division of the State Department of Conservation. The most regular production is from the deepest domes and the world's deepest wells are within 20 miles of New Orleans, at

Lafitte, where oil is being recovered from 9400 to 10,250 feet down.

New methods are being discovered to get accurate information on deep wells and Dr. Shaw is confident that within the next few years there will be widespread production of 12,000 to 15,000 feet right at the door of New Orleans. In 1936, Louisiana produced 78,800,000 barrels of oil and it is expected that, within four or five years, production will be 500,000 barrels daily with field after field in all of the parishes near New Orleans coming into producing power. The oil people look upon Louisiana as the most favorable state for future reserves.

Climate

The mild climate of New Orleans is conducive to year-round production of fruits and vegetables and is an advantage to industry. New Orleans is both a summer and a winter resort. Extreme temperatures do not prevail. It is possible to take part in outdoor sports in December, January, and February. The average temperature in New Orleans in October through March is a comfortable 60.7 degrees, with golf courses always green. The summer average temperature is 78.3 degrees. Only 14 times in 64 years has the temperature gone above 100 degrees. The favorable summer climate is attributable, in part, to the cool, invigorating iodine breezes that sweep the city from the Gulf, the river, and Lake Pontchartrain.

BONNET CARRÉ SPILLWAY

John Klorer Tells of Steps Leading to Building Spillway

In 1922, following the high water of that year, and with the lessons of that flood before them, there was formed the "Safe River Committee of 100," composed of leading citizens of New Orleans and of the Parishes above and below New Orleans, including bankers, railroad representatives, and representatives of other interests having large investments in and about the city of New Orleans. This "Safe River Committee," under the presidency of J. M. Thomson, New Orleans publisher, became a determined and militant organization dedicated to the purpose to do everything possible to give better flood protection to the city of New Orleans than was then afforded by the levee system.

A subcommittee of engineers was selected from its members and was assigned to the task of preparing an engineering report as to what needed to be done to make New Orleans safe against the flood waters of the Mississippi River.

A short but intensive study of the problem was made and a brief was prepared, the principal feature of which was the recommendation that a spillway was to be built as near as practicable to the city and discharging into tide water on the east side of the river. The dimensions of the weir were to be 6000 feet long, with a crest elevation equivalent to fifteen feet on the Carrollton gage. The discharge capacity would be 250,000 cubic feet per second when the Carrollton gage would read twenty feet. The location recommended was about ten miles below the city, this downstream location being preferred to an upstream location to avoid the excessive costs that would be involved in adjusting the lines of communication entering the city from above. The estimated cost was to be five million dollars.

The "Safe River Committee" worked persistently in the effort to get the United States government to construct this flood-reducing device, but received little encouragement. Audiences were had with President Harding and President Coolidge, and finally governmental approval was obtained to the passage of an Act authorizing a survey and study to be made of the practicability of utilizing spillways to reduce flood heights on the lower Mississippi River. This Act provided that the study should be made by United States engineers not connected with the Mississippi River Commission.

The big flood of 1927 came along while this study was being made, and the artificial crevasse at Caernarvon gave ocular proof as to what was needed on the lower river. It was the greatest hydraulic laboratory experiment ever conducted in history. The day-by-day constancy of the Carrollton gage reading from the date of the crevasse April 29 to May 15, while during the same period the Baton Rouge gage rose 2.8 feet, was eloquent testimony as to the efficacy of spillways.

The Spillway Board report was favorable and such a structure was included in the adopted plan of the Flood Control Act of 1928. The location selected was at Bonnet Carré which, from an engineering point of view was preferable, although more costly than the downstream location would have been.

The Bonnet Carré Spillway has a length of weir 7700 feet at the river and with a cross elevation of 16 m.g.l. for 1914 feet of its length, and a crest elevation of 18 m.g.l. for 5785 feet of its length; the equivalent readings on the Carrollton gage would be three or four feet less than these elevations, the difference being due to the high water slope of the river. The theoretical discharge is 275,000 cubic feet per second when the Carrollton gage reads twenty feet. The cost of the structure and guide levees was $6,400,000, the rights-of-way $738,000, the highway bridge $820,000, the railroad bridge $5,000,000, or a total of $13,000,000, in round figures.

The people of New Orleans may now enjoy a feeling of security even though the stage of the river gets near the 20-foot mark on the Carrollton gage for they have the comforting assurance that "Old Man River" will be definitely and positively kept from going beyond that height.

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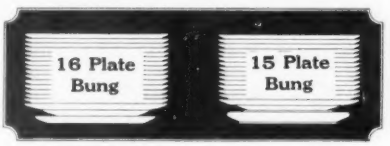

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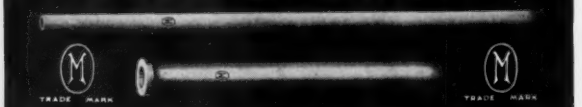
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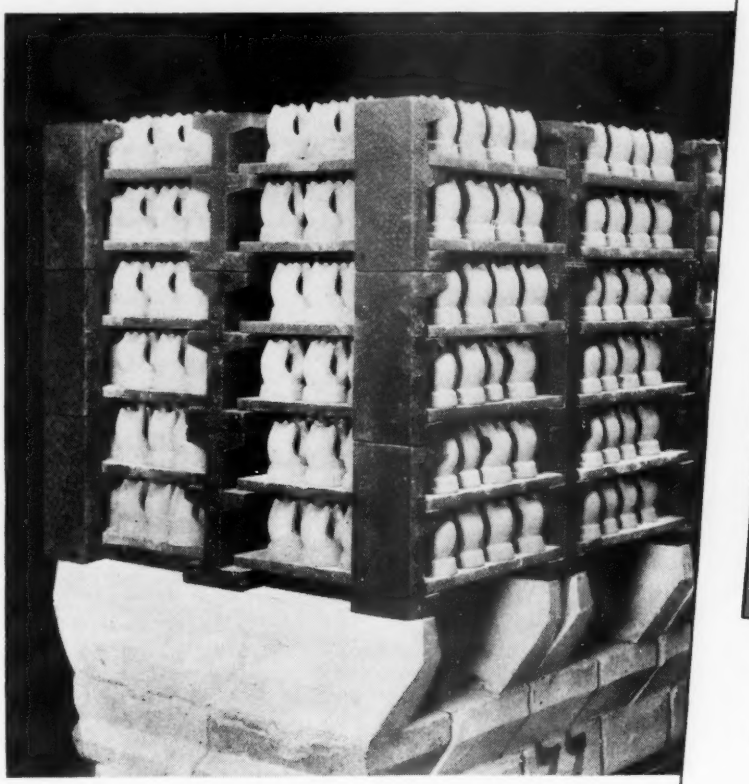

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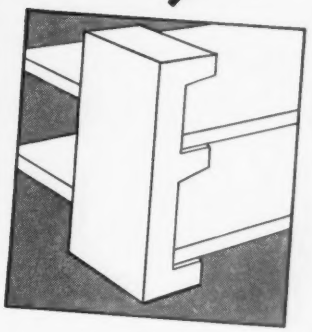

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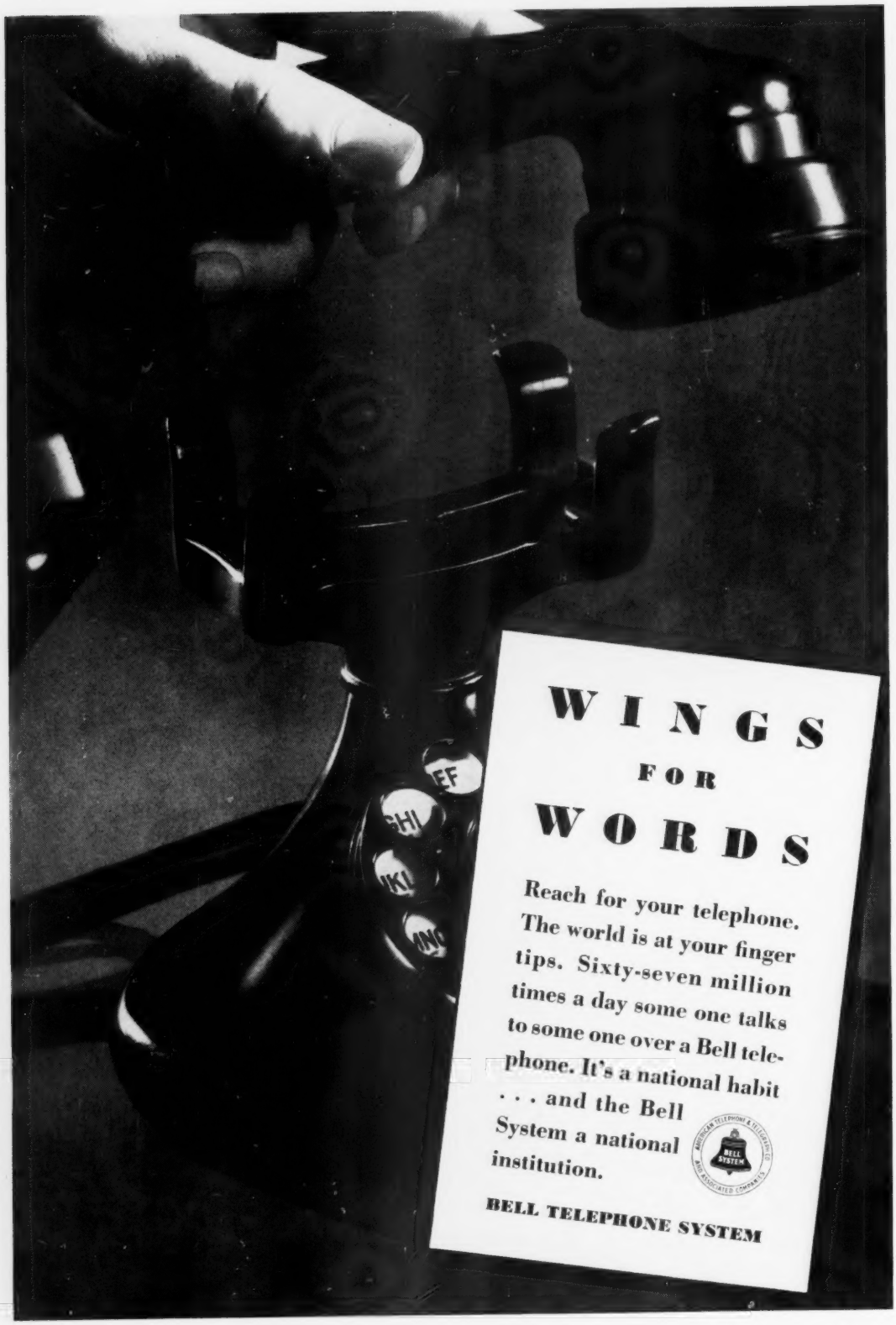
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